Dear Editor,

First of all, we acknowledge both Reviewers and Stephen Saleeby for their useful comments and for the precise review that improved the quality of the paper. All comments were considered and our answers are detailed below in blue.

Reviewer #1

This study uses ground-based measurements in Italy as to evaluate the GHI estimations from MSG and RAMS in hourly basis. Then, a correction technique was performed in order to improve the comparison results.
The scientific quality and presentation of the paper is very good and with some minor technical corrections and revisions, it could be a valuable publication in the AMT journal.
First of all the MOS correction needs to briefly described in the ”Data and Methods” section in order to provide a connection with the application results in sub-section 3.3.

We have moved the MOS description in the “Data and Methods” section.

The authors could provide some references for the uncertainties in cloud-properties and MACC outputs, and discuss the sensitivity of these parameters to the MSG-GHI evaluated values.

We have commented a bit on the uncertainty in cloud properties and MACC output, adding some references on the subject. We wrote:

“The retrieval of cloud properties can be associated with large uncertainties, in particular due to horizontal inhomogeneity (e.g., Coakley et al., 2005). However, subsequently derived irradiances (such as SICCS GHI) have relatively much smaller uncertainty due to compensation of errors in forward and inverse radiative transfer calculations (Greuell et al., 2013; see also Kato et al., 2006). Uncertainties in MACC reanalysed aerosol properties contribute to errors in retrieved clear-sky GHI but these errors are considerably smaller than those for cloudy skies (Greuell et al., 2013).”

The same literature-based uncertainty and sensitivity analysis need to be discussed for the RAMS, as to directly connect with the evaluation results presented, by providing comparable specific ranges and values as well.

We acknowledge the Reviewer and Stephen Saleeby for this specific comment on the RAMS model. We clarified the uncertainties that are expected with our version of the RAMS model, considering recent developments to the model as well as results obtained with different models. We wrote:

"The results of this paper are representative of the current operational implementation of the RAMS model at ISAC-CNR. There have been recent improvements to the RAMS model (CSU-RAMS, http://vandenheever.atmos.colostate.edu/vdhpage/rams.php) that will be explored in future studies to improve the GHI forecast. The errors of the RAMS forecast for the GHI can be divided in three, non-exhaustive, main components: a) errors in the prediction of the cloud coverage; b) errors in the simulation of the interaction between the radiation and the clouds; c) errors in the representation of the aerosol effects on the GHI.

As shown by the results of this and others papers, the error (RMSE) on the prediction of the GHI is of the order of the GHI when the cloud coverage is not well represented. Errors by both physical and numerical parameterizations of the model, but also errors in the initial and boundary conditions contribute to this issue. In particular, the microphysical scheme influences the whole simulation through a multitude of dynamic, radiative, thermodynamic and microphysics processes. The WSM6 scheme used in this paper is a single-moment scheme, predicting the mixing ratios of six hydrometeors (vapour, cloud, rain, graupel, ice, snow). The WSM6 gave better performance compared to other single-moment microphysics schemes included in RAMS for twenty cases over Italy characterized by widespread convection and, for this reason, it is used in the operational implementation at ISAC-CNR. However, the inability of single-moment schemes to allow the number concentration and mean diameter of hydrometeors to vary independently limits their ability to simulate clouds with characteristics consistent with observations across a wide range of atmospheric conditions. Also, the sensitivity of these schemes to fixed parameters as, for example, the number concentration of the hydrometeors, is high (Igel et al., 2015).

When both the mixing-ratio and number concentration can be predicted, as in double-moment schemes, the description of the physical processes as condensation, collision-coalescence, and sedimentation is improved. For this reason, double-moment schemes outperform single-moment schemes as shown in several studies (Igel et al., 2015 and references therein).

The CSU-RAMS model includes a double-moment microphysics scheme (Meyers et al., 1997) that could improve the prediction of the cloud coverage and will be considered in future studies.

Also, the cumulus parameterization scheme has an important role on the NWP forecast, especially for cloud prediction. In addition to the Kuo scheme, used in this paper for the first domain, RAMS implements the Kain-Fritsch scheme (Castro et al., 2005). This scheme will be used in future studies to assess the sensitivity of the performance to the choice of the cumulus parameterization scheme.

Another important point to consider for improving the model performance of the GHI forecast is the change in the optical properties of the clouds when the liquid and ice phases are considered in the radiative scheme (Harrington et Olsson, 2001; Sun and Shine, 1995). The Chen and Cotton scheme (Chen and Cotton, 1983) used in this paper, while fast and efficient from the computational point of view, considers the total condensate in the atmosphere but not the phase of the water (i.e. ice, liquid or mixed). Numerical and observational experiments (Harrington et Olsson, 2001; Sun and Shine, 1995) show that the impact of the water phase is significant for the computation of the GHI because the absorption and emissions are largely reduced in ice compared to liquid path with the same water path.

Finally, our radiative scheme neglects the impact of the aerosols. This impact, however, can be very important. For example, Lara-Fanego et al. (2012) show that the overestimation of the GHI by WRF over Andalucia in clear sky conditions was caused by the underestimation of the aerosol optical depth (AOD), which was assumed 0.1 for their experiments. Zamora et al. (2005) showed that a doubling of the AOD considered in the Dudhia scheme (Dudhia, 1989) was responsible for a decrease of the GHI of about 100

W/m^2 at the solar noon over US. Kosmopulos et al. (2017) investigates the impact of an extremely high dust event (maximum AOD 3.5), occurred from 30 January to 3 February 2015 over Greece. For this event, they found an attenuation of the GHI up to 40-50 %. They also show that, for climatological conditions, the attenuation of the GHI by the aerosol load is less than 10%. Considering the above results and the fact that the RMSE statistic used in this paper is sensitive to large errors, an important impact of the aerosols is expected. The Harrington et al. (1997) radiation scheme is aerosol sensitive, is available in CSU-RAMS, and will be tested in future studies."

Finally, the conclusions section need to be merged into some additional general findings, highlighting the innovation and value of this study.

Considering this comment and that of the Reviewer #2 about the conclusions, the "Conclusion" section ("Summary and Conclusions" in the revised version) has been shortened about the statistics shown in the paper, while the results have been compared with similar studies in other Mediterranean countries (Greece and Spain, see the answer to the Reviewer #2 for details). Also, a discussion on the specific version of the RAMS model used in this paper (above comment) has been included considering the recent developments of the model.

Overall, the presented techniques are scientifically sufficient, the results are well determined and falls into the scope of AMT, so I believe that after the above minor corrections, the paper can be published.

Reviewer #2

REVIEW OF MANUSCRIPT SUBMITTED TO Atmos. Meas. Tech. Discuss.

Authors: Stefano Federico, Rosa Claudia Torcasio, Paolo Sanò, Daniele Casella, Monica Campanelli, Jan Fokke Meirink, Ping Wang, Stefania Vergari, Henri Diémoz, Stefano Dietrich

Title: Comparison of hourly surface downwelling solar radiation estimated from MSG/SEVIRI and forecast by RAMS model with pyranometers over Italy

Date of review: 02 APR 2017

OVERALL EVALUATION

The manuscript presents a one-year comparison between satellite-estimated and numerical weather prediction model –forecasted solar radiation with ground- based measurements at Italian sites. The paper is of interest as it involves both weather forecasting and satellite algorithms, considering a topical subject connected to solar energy production.

The manuscript presents a fairly thorough evaluation of the performance of these two sources of solar radiation information for the chosen Italian sites. The figures presented and the used equations seem correct. However, the manuscript occasionally presents conclusions that are not supported by the evidence presented in this study, and furthermore suffers from unclear sentences that perhaps could be improved through a proper language check / proof reading.

I would recommend major revisions before accepting this manuscript. Note, however, that I do not believe that the actual scientific work will require a deep revision, but rather, that the authors need to pay attention to way things are expressed and what conclusions can be made based on the results presented in their manuscript.

SOMEWHAT GENERAL COMMENTS

- L59-61 and elsewhere: throughout the manuscript, it would be important to emphasize (and remind the reader of the fact) that RAMS is a forecast (for the day ahead), and MSG-GHI is a satellite-based estimate (available some time after the satellite observations have been made). This needs to always be kept in mind when comparing the performance of the two – the present manuscript is occasionally somewhat sloppy on this.

-Ok. Clarified throughout the paper. Where appropriate we used: "RAMS-GHI one-day hourly forecast"

- L110—118: The RAMS model should be properly introduced before starting the paragraph on exchange between atmosphere and surface. What is the RAMS model?

- Thank you for noting this point. We wrote: "RAMS is a general purpose limited area model designed to be used at the mesoscale (horizontal grid spacing ≈ 1-100 km) or higher horizontal resolutions. It is based on a full set of non-hydrostatic, compressible equations of the atmospheric dynamics and thermodynamics, plus conservation equations for scalar quantities such as water vapour and liquid and ice hydrometeor mixing ratios. The model is widely used for research as well as for weather forecast (Cotton et al., 2003)."

- L151—164: The text seems somewhat unclear here, should be clarified. It seems to me that maybe there are two different groups of pyranometers used: (i) L151-157, and (ii) L158-164. The stability of the pyranometer in Aosta is documented, but nothing is said about the other pyranometers. If sunshine duration is used (point 2), which stations have sunshine duration available? How is the Aosta check against libRadtran done, what are the criteria for data removal? Which institutes are responsible for the pyranometer measurements?

The pyranometers are managed by two different institutions and each institution is responsible for its own observations. The Aosta pyranometer is managed by Arpa Valle D'Aosta, while all other pyranometers are managed by the Aeronautica Militare. The check with the LibRadtran software for Aosta is made to test for electric wiring faults. In particular, measurements higher than 200% of the daily maximum expected from libRadtran in clear-sky conditions are removed. A comment was added for the stability of the Italian Air Force (Aeronautica Militare) pyranometers.

To clarify these points, we wrote:

"The pyranometers are managed by two different institutions. The Aosta pyranometer is managed by Arpa Valle D'Aosta, while all other pyranometers are managed by the Italian Air Force (Aeronautica Militare). Each institution is responsible for its own measurements.

For pyranometers managed by the Italian Air Force, in addition to basic maintenance and installing procedures recommended by WMO – Guide nr. 8, data quality is controlled following an internal control procedure described in Vergari et al. (2010).

In particular, to improve quality control checks for global solar radiation and sunshine duration data (available simultaneously for all stations of this paper managed by Aeronautica Militare), two procedures have been implemented. A range limit check, applied to both variables separately, concerns the respect of variables' physical limits. This check has been improved varying physical limits in agreement to the latitude and the season. Furthermore, the monthly atmospheric clearness index has been calculated from the climatic history of each site, by applying the linear form of the Angstrom-Prescott model. Then, an upper and a lower bound for the solar radiation are defined as linear functions of clearness index and the sunshine duration value. These bounds delimit the range of the daily solar radiation.

Analyzing the distance of daily values from their bounds, it is also possible to prevent instrumental electronic drifts. In fact, if this distance changes in an appreciable way, a recalibration procedure is activated and the device is recalibrated by comparison with a standard pyranometer using the sun as a source, under natural conditions of exposure (ISO ,1993). The reference standard used in this case is a CM11 Kipp and Zonen, calibrated every two year by the WMO Regional Instrument Centre Radiation of Carprentrass (France), by comparison with a pyreliometer PMO6 and a pyranometer CMP21.

For the Aosta pyranometer, in addition to the manual maintenance related to the periodical cleaning of the dome, irradiance measurements are daily checked through comparison with clear-sky simulations by a radiative transfer model (libRadtran, Emde et al., 2016) to check for electric wiring faults. In particular, measurements higher than 200% of the daily maximum expected from libRadtran in clear-sky conditions are removed. The CMP21 radiometer is calibrated every two years at the Physikalisch-Meteorologisches Observatorium Davos/World Radiation Center (PMOD/WRC) against a member of the World Standard Group (WSG) for the direct component and a shaded standard pyranometer of the World Radiation Center (WRC) for the diffuse component. The radiometric stability was better than 0.2% over the period of the six years of measurements."

- Fig 6 + analysis: The manuscript up to this point has explained/speculated about the role of clouds in the performance. Now, Fig 6 finally shows quantitative results on how the performance behaves as a function of cloud classification. To me, it would make sense to bring this figure more toward the early part of the manuscript, so that the remaining analysis already could make use of these results as this would reduce the need for indirect determination.

- Thank you for noting this point. We moved the analysis of Figure 6 (Figure 4 in the revised version) at the end of Section 3.1 to show the impact of the cloud coverage on the RAMS-GHI forecast and MSG-GHI estimation performance for all stations. We believe that this clarifies the following analysis, as you suggested.

- Conclusions -> (suggestion) Summary and Conclusion: The section is in its present form to a large extent repeating/summarizing the results presented in previous sections. It would be more interesting for the reader if some more discussion/conclusions would be added. Perhaps the section could also be shortened.

-Considering this comment and that of the Reviewer #1 about the conclusions, the "Conclusion" section ("Summary and Conclusions" in the revised version) has been shortened about the results of this paper, while the results of the paper have been compared with similar studies in other Mediterranean countries. Also, a discussion on the specific version of the RAMS model used in this paper will be included considering the recent developments to the model. The discussion on the specific version of the RAMS model is reported in the answer to the Reviewer #1, while here we show the discussion on the comparison with similar studies in the Mediterranean countries (Spain, Greece). We wrote:

"To put the results of this paper in a more general context, we compare our statistics with similar studies in the Mediterranean area (Greece and Spain).

Kosmopulos et al. (2015) quantified the performance of the MM5 model for the one- and two-days forecast over Greece. The forecast was compared with eleven pyranometers displaced over the country. The RMSE computed from hourly data and for the one-day forecast ranges between 160 W/m^2 for the Chania station to 230 W/m^2 for Amfiklia. The error increases with the terrain complexity and cloud coverage: Chania is located in the western part of the Crete Island and shows a Mediterranean climate, while Amfiklia is located in one of the highest plateaus of Greece, bounded at the west by the Pindos mountain. The RMSE shows a small increase between the first and second day of forecast. With the exception of the mountainous stations of this paper, where the RMSE is larger, our performance is in line with that of Kosmopulos et al. (2015). Also, both studies show a positive MBE with values of few tens of W/m^2 for most stations, with the exception of Paganella and Aosta stations of this study where the MBE is larger in absolute value.

Gómez et al. (2016) quantified the performance of the RAMS model (both versions 4.4 and 6.0) for the one-, two- and three-days GHI forecast over the Valencia Region. They considered thirteen pyranometers widespread over the region. Focusing on the RMSE for hourly data in summer, they found errors of 200 W/m^2 for flat terrain and 250 W/m^2 for hilly terrain. The RMSE for winter is 150-160 W/m^2, depending on the stations. The MBE is of few tens of W/m^2 and it is positive. They found similar results among the three days of forecast and also between the two versions of the RAMS model. With the exceptions of the mountainous stations of this paper, where both the RMSE and MBE in absolute value are larger, our results are in line with those of Gómez et al. (2016).

Lara Fanego et al. (2012) examined the performance of the WRF model for the GHI one- two- and three-days forecast over Andalucia (Spain). They consider four stations: Andasol, Jerez, Cordoba and Huelva. The RMSE computed from hourly data for the whole year is 140 W/m^2 for Cordoba, Jerez ad Huelva stations and 170 W/m^2 for Andasol. Differences of the RMSE among the three days of forecast are small. The RMSE of Lara Fanego et al. (2012) is smaller (10-20 W/m^2) than those of this paper.

This result can be caused by the difference of the climate and orography at the stations considered in the two studies, nevertheless a better treatment of the interaction between aerosols and radiation in Lara Fanego et al. (2012) contribute to this difference. The MBE of Lara Fanego et al (2012) is in line with that of this paper, with the exception of Paganella and Aosta stations."

- L448: Are any evidence presented in the manuscript that show that the radiative scheme is unable to simulate cloudy conditions correctly? Where does this statement come from?

- We agree that the worse simulation of the GHI in cloudy conditions in not necessarily a consequence of the radiative scheme as other errors, for example the estimation of the hydrometeor concentrations, have a role. We modified the sentence and we wrote: "The increase of the RMSE with the cloud coverage is a combination of both the inability of the two methods to correctly represent the cloud coverage and of the difficulty to compute the GHI in cloudy conditions."

SPECIFIC SUGGESTIONS

- L25-26: this is not always true (see e.g. L445—446).

We modified the sentence: "Results for hourly data show an evident dependence on the sky conditions, with the Root Mean Square Error (RMSE) increasing from clear to cloudy conditions."

- L27: RMSE increases for Alpine stations (and similar statements elsewhere). This seems a bit misleading. I would suggest saying "is higher" or "is lower".

- Corrected according to the Reviewer comment.

- L30: "RMSE ranges from 152 W/m2 to..." – here (and elsewhere) it should be defined that the RMSE has been calculated for hourly values.

- Corrected according to the Reviewer comment.

- L36: "a reduction" -> "lower"

-Ok. We wrote "Results for daily integrated GHI show lower RMSE compared to hourly GHI evaluation for both RAMS-GHI one-day forecast and MSG-GHI estimate. Considering the yearly evaluation, the RMSE of daily integrated GHI is at least 9% lower (in percentage units, from 31% to 22% for RAMS for Cozzo Spadaro) than the RMSE computed for hourly data for each station."

- L36: "of at least 10%" – here, it needs to defined what 10% means (10% of the base value, or a change corresponding to 10% steps/units (e.g. from 20 to 10%). Also elsewhere.

-Thanks for this point: the value refers to a change in the percentage units (as in the previous comment). Clarified throughout the paper.

- L46: two specific papers are cited for a scope very wide. I would suggest removing the references.

-Done.

- L51: Yes, PV can convert GHI to electricity, but much more commonly, they convert tilted GHI, or perhaps more generally, just solar radiation, to electricity.

- Corrected. We used "solar radiation".

- L91: suggest to remove "So"

- Done.

- L92: particle size is not an optical property

- Deleted.

- L94: could you clarify the text here, is a mixture of ice/water clouds possible?

- Clarified: a mixture of ice/water cloud is not possible.

- L112: "most of Europe" seems a bit exaggerated

- Corrected: "Central Europe"

- L131-132: Somewhat unclear what exactly this means. Could be elaborated more.

We added the following part to clarify the point: "In particular, the scheme uses an "effective emissivity" for cloud layers, where the cloud emissivity is parametrized empirically from observations (Stephens 1978). The "effective emissivity" is a function of the total condensate water path, computed summing all hydrometeors mixing ratios (liquid, i.e. cloud and rain, solid, i.e. ice and snow, and mixed phase, i. e. graupel) and integrating over the cloud-layer (Chen and Cotton, 1983).". In the "Summary and Conclusion" section it is also discussed the important impact of taking into account for the different phases of the condensate water.

- L133-136: Please clarify, are there any additional data assimilated into the RAMS model, e.g. weather observations, or is the RAMS model's initial state fully determined purely by ECMWF?

No additional data are assimilated into the RAMS model and the initial state is fully determined by the ECMWF. We wrote: "No additional data are assimilated into the RAMS model."

- L138-139: Seems contradicting that a weather forecasting model would need a spin up time of 12 hours.

- The model configuration of this paper uses a cold start with no hydrometeors, with the exception of the water vapour, at initial time. Previous unpublished studies with RAMS showed that 12 h are enough for the model to reach a dynamical equilibrium between the dynamic, thermodynamic and cloud-precipitation fields starting from a cold start. The 6 h spin-up time is enough for most cases, but there are occasions where a longer spin-up time is required. We consider this point as follows:

"The model was run for a whole year (1 June 2013 - 31 May 2014) with the above configuration and with no hydrometeors at the initial time, with the exception of water vapour (cold start). Previous unpublished studies with RAMS showed that 12 h are enough for the model to reach a dynamical equilibrium between the dynamic, thermodynamic and cloud-precipitation fields starting from a cold start. For this reason, each simulation lasts 36 h, starts at 12 UTC of the day before the day of interest, and the first 12 h are used as spin-up time and discarded. The model output is available hourly."

- Section 2.3: could be separated into two: (i) surface observations / (ii) evaluation methodology

- We separated the section in two parts, as it seems clearer.

- L146: "Vigna di Valle is still" -> "Vigna de Valle is" (remove still)

- Done.

- L165: "environmental characteristics" seem to actually mean cloud classification by the satellite method, is that correct? Please clarify text and use suitable terminology.

- We changed the sentence: "Table 3 shows, for each station and season, as well as for the whole year, the percentage of data in clear, contaminated and overcast conditions, classified by the satellite method of Section 2.1."

- L170: (language) "with the stations" -> "between different stations" ?

- Corrected.

- L174-175: somewhat unclear sentence, please clarify

- Rephrased: "The RAMS GHI forecast is available hourly, while the frequency of pyranometer observations and MSG-GHI estimate is every half an hour. Pyranometer observations and MSG-GHI estimates were considered hourly, at the same time of the RAMS forecast output."

- L178-179 + L188-189: why not use equation numbers?

- We added the equation numbers.

- Figure 3: I would suggest swapping the axes, so that pyranometer values are on the x-axis and estimated values on the y-axis. This makes values above the 1:1 line correspond to overestimation and vice versa, which is more logical. Also, I think it would be interesting to add this kind of figure for each station as a supplement or appendix as some readers will be interested in that information. Finally, the figure would be easier to read if grid lines and a legend were added, and if the point style would be modified so that points would not overlap (as much) in the busy areas of the plot.

- Figure 3 was changed according to this comment. The Figures for other stations will be added as a supplement to the paper (and are shown at the end of this answer for completeness).

- L196 / Fig. 3: clarify how the regression lines were determined

- Clarified. Linear regression is computed using the pyranometer values as *x* and MSG-GHI estimation (Figure 3a) or RAMS-GHI one-day ahead hourly forecast (Figure 3b) as *y*. The black regression line is for clear sky, the red one is for cloudy conditions (both contaminated and overcast), the blue is for all the dataset. This has been clarified both into the text and adding a legend to Figure 3.

- L201-202 and L220: “it is apparent the larger scatter” -> (language) please rephrase (also similar sentence construction elsewhere)

- Rephrased: “The data for cloudy conditions of Figure 3a show larger deviations from their regression line compared to clear sky data.” Also in line 220: “The RAMS-GHI forecast data show larger deviations from their regression line compared to MSG-GHI.”. Also in lines 210-211 “b) the correlation coefficient for cloudy conditions is lower compared to clear sky data and shows….”.

- L229-230: in point b, it needs to be emphasized that RAMS is a forecast and thus not directly comparable to MSG.

- Ok. We wrote: “For the latter point, however, it is emphasized that the MSG and RAMS performance cannot be directly compared because RAMS is a forecast, while MSG gives an estimate of the GHI from radiance observations”.

- L256-257: It is unclear to the reader how the conclusion about clouds being the main source of error was made. Could this be elaborated?

- In the revised version of the paper there will be a reference to the supplement where we show the scatter plots of the GHI for the pyranometer and RAMS-GHI forecast. From these figures is apparent the over forecast of cloudy conditions by RAMS for the pyranometers of Paganella and Aosta (points in the lower part of the figures). We wrote: “The inspection of the model output for those stations reveals that the main source of error was the over forecast of cloudy conditions, as shown by the scatter plots between the RAMS-GHI one-day hourly forecast and the corresponding pyranometer values for these stations, given as a supplement to this paper"

- L257-264: This seems to be mostly somewhat loose speculation, although things are expressed as hard facts. The evidence presented in the manuscript does not support all these statements. Therefore, I recommend rewriting, to use more careful statements.

-Lines 262-264 were removed, while the rest of the discussion was rewritten using more careful statements. We wrote: "It is not easy to find the reason for this behaviour, because several factors could be involved as errors in the physical and numerical parameterizations of the model, and errors in the initial and boundary conditions. Also, the 4 km horizontal resolution is not enough to resolve the fine orographic structures over the Alps (Aosta and Paganella) and over the Apennines (Monte Cimone), and their interaction with the atmosphere. "

- L268-274: On a general level, I believe the explanations presented here to be plausible. However, I also find that the authors focus too much on explanations that have to do with local orography and horizontal resolution. Could there be something else involved as well? For example, one factor that certainly plays a role here is the fact that mountain stations have more clouds and clouds are difficult for the satellite algorithm (as seen later on in Fig 6).

-We added the following reasons: "…b) The classification of sky conditions is more difficult where the soil is covered by snow and, because this condition is more frequent for mountainous stations, it increases the MSG-GHI error for those stations; c) The estimate of the hourly GHI by the MSG is more difficult in cloudy conditions (Figure 4), which are more frequent for mountainous stations."

- L287: RMSE -> rRMSE?

- Corrected.

- L288-289: unclear to me what is meant by "statistic shows more clearly the impact of ..."

- Corrected. "… this analysis …."

- L294 + Fig 5 caption: "RAMS-GHI one-day forecast". Here (and elsewhere when mentioning RAMS one-day forecast) it would be important to emphasize that RMSE is based on hourly values of the day ahead forecast from RAMS. The present text leads me to think that values may be daily.

- Clarified throughout the paper. We used "RAMS-GHI one-day hourly forecast" where appropriate.

- L301: I find it odd to say "This result is caused by RMSE statistics".

- Corrected. "This result is caused by the large differences between the RAMS-GHI one-day hourly forecast and observations."

- L321: “all sky conditions, which showed” -> (suggest) “all sky conditions, which indirectly showed...”

- Changed.

- L329-331: Unclear how this explains the difference?

- We removed the sentence because it was misleading.

- L333: Not completely true, compare with L445-446

- Corrected. We considered only two classes: clear and cloudy.

- L344-346: Please clarify how the persistence forecast is created. Are values hour by hour assumed to be the same between the two days?

-Clarified. We wrote: “The one-day hourly persistence forecast was computed using hour by hour the observed values of the previous day”.

- L345: I find the use of the short-version “1D” somewhat misleading (as it makes me think of one-dimensional) and therefore suggest writing it out: one-day.

-Ok. Corrected everywhere.

- Section 3.3: split into two separate sections? (i) Daily evaluation / (ii) MOS application

-We divided Section 3.3 in two sections according to this comment.

- L381-383: There may also be other sources of MBE

-We modified the sentence according to this comment. We wrote:

“The MOS technique improves the forecast/estimate of the GHI by reducing the MBE. The MBE is caused by several factors related to both modelling and observations. In the context of this paper the most important causes of MBE are: a) the approximations in the meteorological model and in the methodology used to estimate GHI from MSG data, and; b) the horizontal grid used to represent the real world, which smoothens the surface features causing systematic errors. Other contributions arise from small and undetected systematic errors in the observations, and from the not exact simultaneity of the three datasets (pyranometers, MSG-GHI, RAMS-GHI forecast). “

- L384: “The MOS consists of” -> (suggestion) “The MOS used here consists of”

-Ok. Corrected. The introduction on MOS has been moved in section 2.4.

- L389-393: Unclear how exactly this works, please clarify.

We clarified the methodology. We wrote "This method is a cross-validation method to assess how the MOS prediction will perform in practice. For each hour of a season, the dataset is divided in two parts: a) the actual data (or actual value), which is the value at the selected hour of the RAMS one-day hourly forecast (or the MSG hourly estimate of GHI) and the corresponding pyranometer observation, and: b) the training dataset, which is composed by all data in the season with the exception of the actual data. The Eqn. (5) is computed for the training dataset (y is the pyranometer value and x is the RAMS one-day hourly forecast or MSG hourly estimate of GHI), and it is applied to the actual data, which is the x, to give the corrected forecast (y). Because the MOS is computed starting from hourly data, the training period is all the season but one hour. This procedure was repeated for all the hourly data in the season, obtaining the time series of the corrected RAMS one-day hourly forecast and of the corrected MSG hourly estimation of the GHI. The RMSE and rRMSE were computed for the corrected forecast/estimate of the GHI. In this way, the data used for computing MOS is statistically independent from the dataset used for the verification."

- L402: Somewhat unclear how this conclusion can be made based on the above sentences.

-Ok. We removed the sentence because it is not a direct consequence of the above sentences.

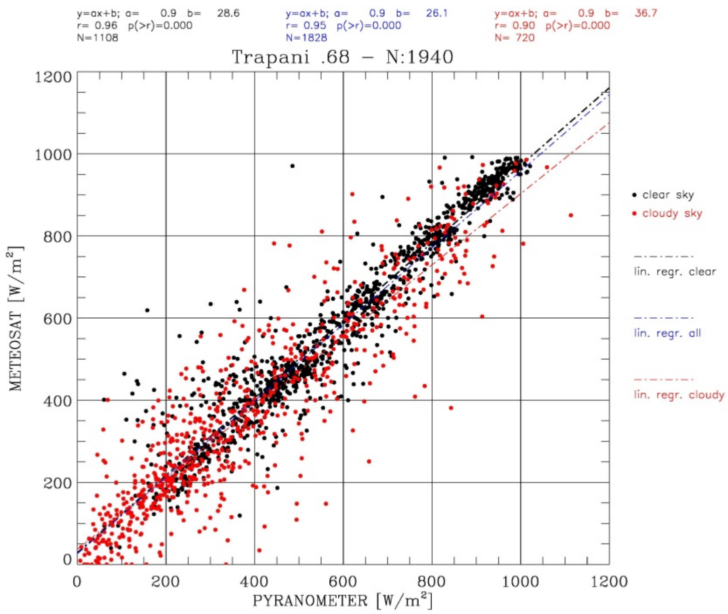
- L436-440 / L441-446: the latter paragraph presents discussion on performance as function of cloud classification, while the previous contains similar information, but indirectly. Maybe the paragraphs could be combined into one, or the order be changed, to make more effective and convincing communication.

-We changed the order of the two paragraphs and we joined them. We wrote: "The cloud coverage has an important impact also on the RMSE of both MSG-GHI hourly estimate and RAMS-GHI one-day hourly forecast. The error is higher for cloudy conditions compared to clear sky. This is especially evident for RAMS because the RMSE averaged over all the stations varies from 91 W/m^2, to 191 W/m^2, and to 245 W/m^2 for clear, contaminated and overcast conditions, respectively; for MSG-GHI, the RMSE averaged over all stations varies from 68 W/m^2, to 123 W/m^2, and to 98 W/m^2 for clear, contaminated and overcast conditions, respectively. However, the analysis of the rRMSE reveals more clearly the impact of the cloud coverage on the performance. Both RAMS-GHI one-day hourly forecast and MSG-GHI hourly estimate show the largest rRMSE in winter and the lowest in summer, following the behaviour of the cloud coverage. "

Supplemental material

In the following, according to the suggestion of Reviewer #2, we show the scatterplots of the pyranometers and MSG-GHI hourly estimate (Figures 1-12 a) and the scatterplots of the pyranometers and RAMS-GHI one-day ahead hourly forecast (Figures 1-12 b) for all the stations considered in this paper. These Figures will be given as a supplement to the paper.

a)



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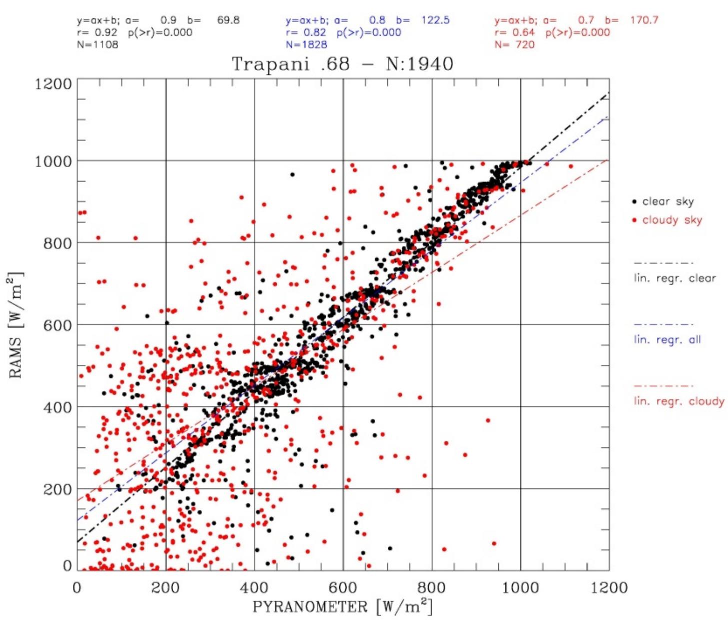
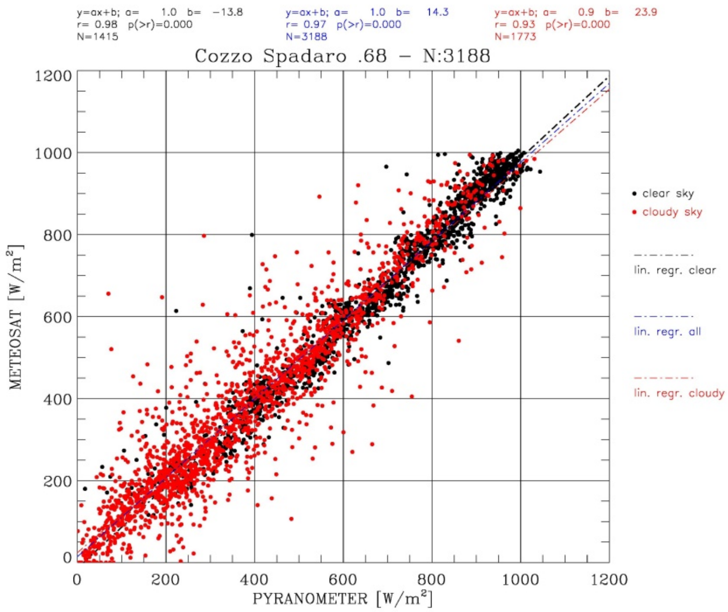


Figure 1 – Trapani (tra): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).

a)



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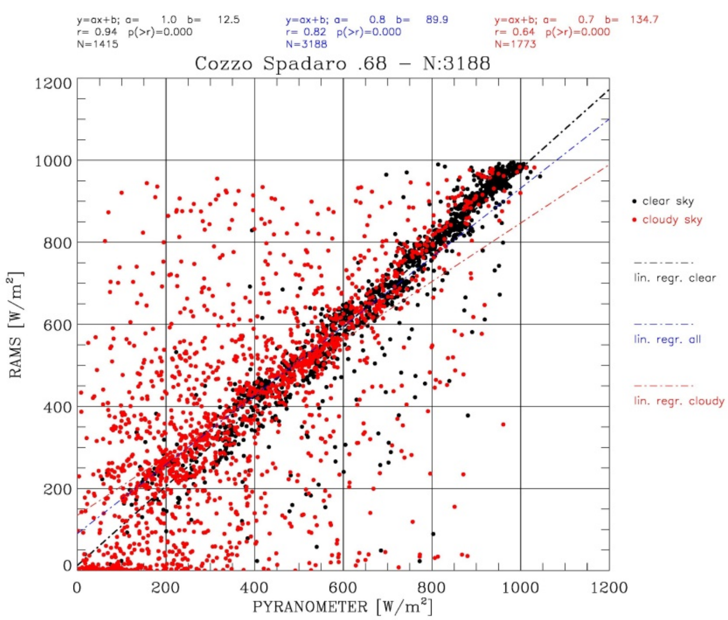
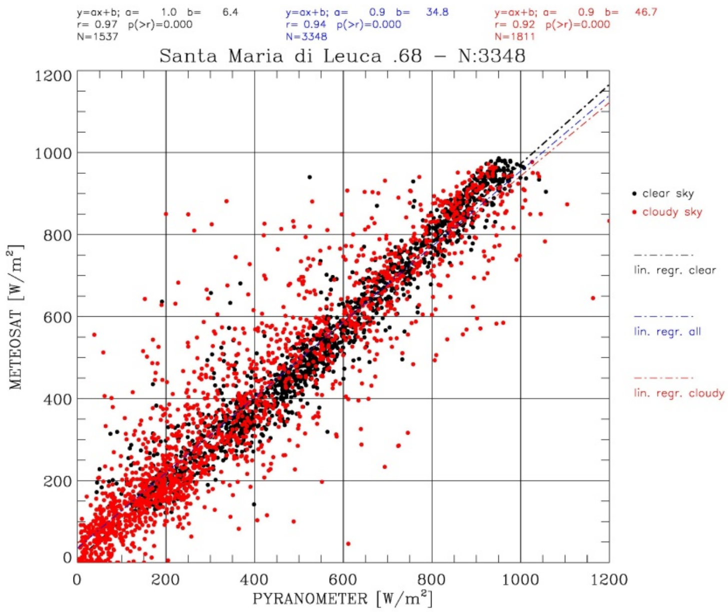


Figure 2 – Cozzo Spadaro (csp): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).

a)



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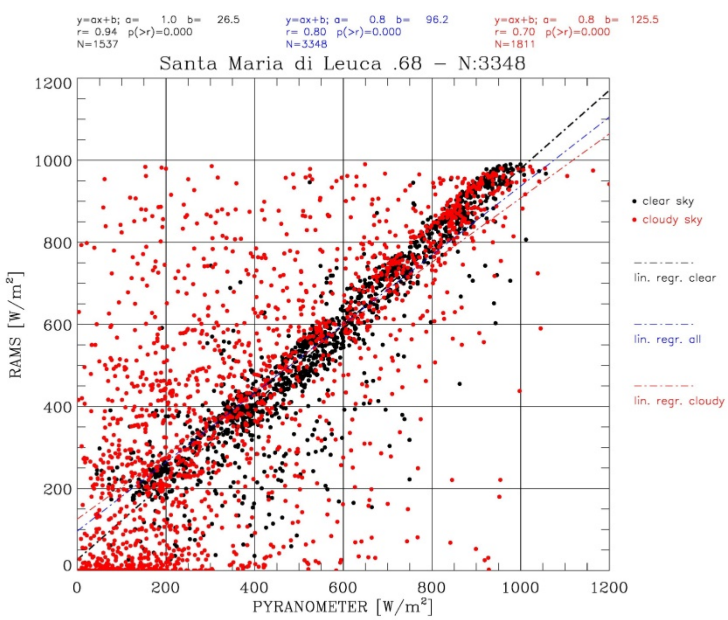
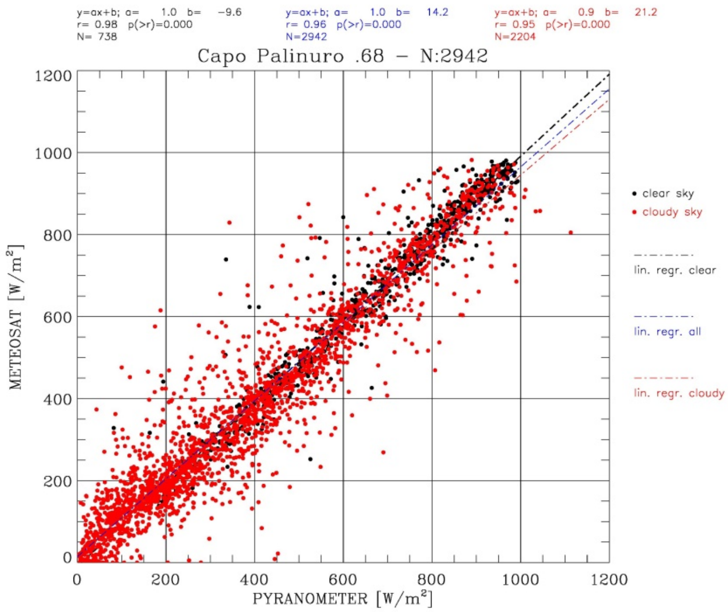


Figure 3 – Santa Maria di Leuca (sml): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).

a)



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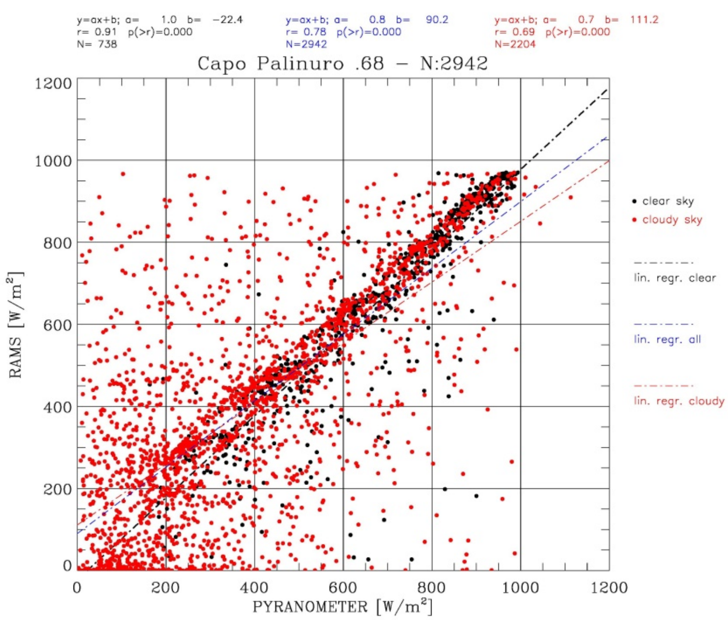
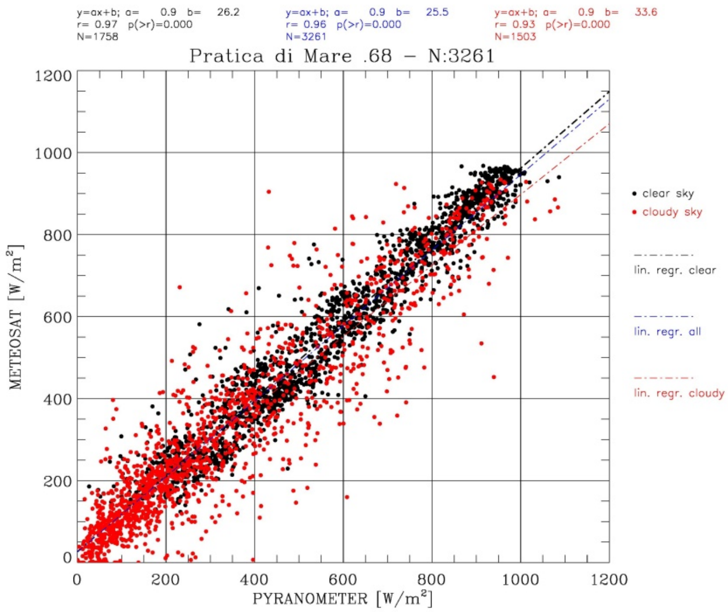


Figure 4 – Palinuro (pal): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).

a)



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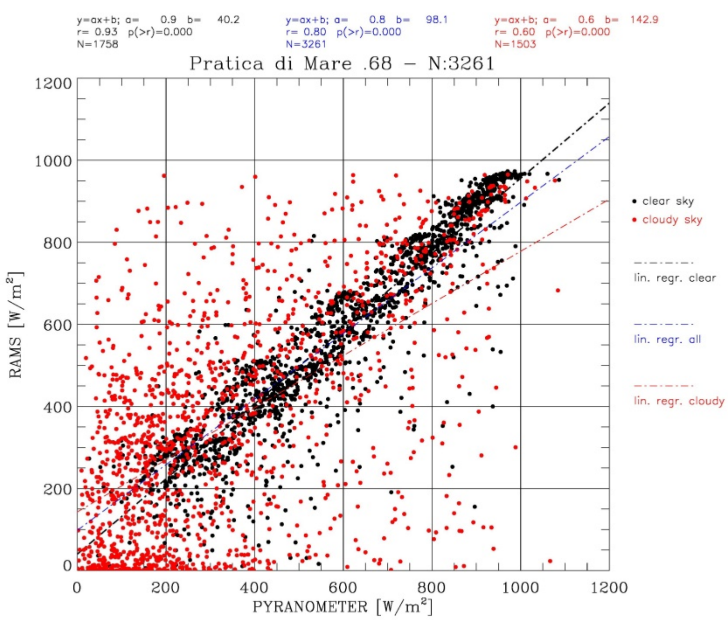
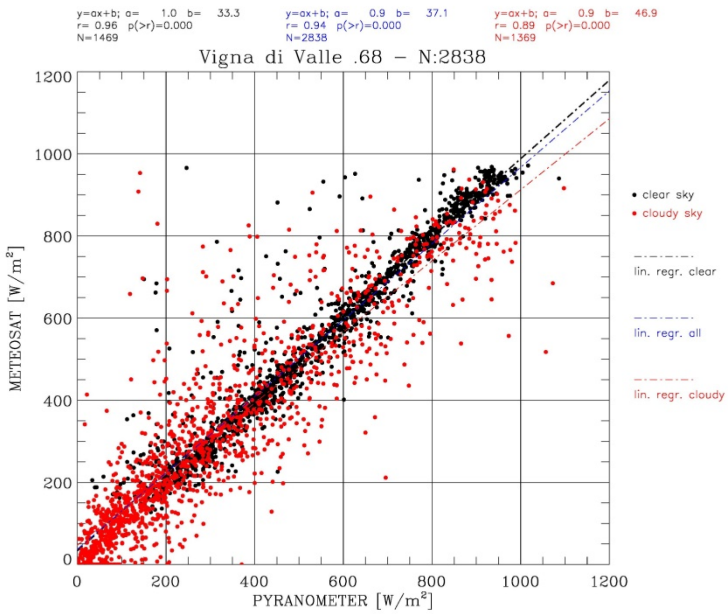


Figure 5 – Pratica di Mare (pdm): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).

a)



b)

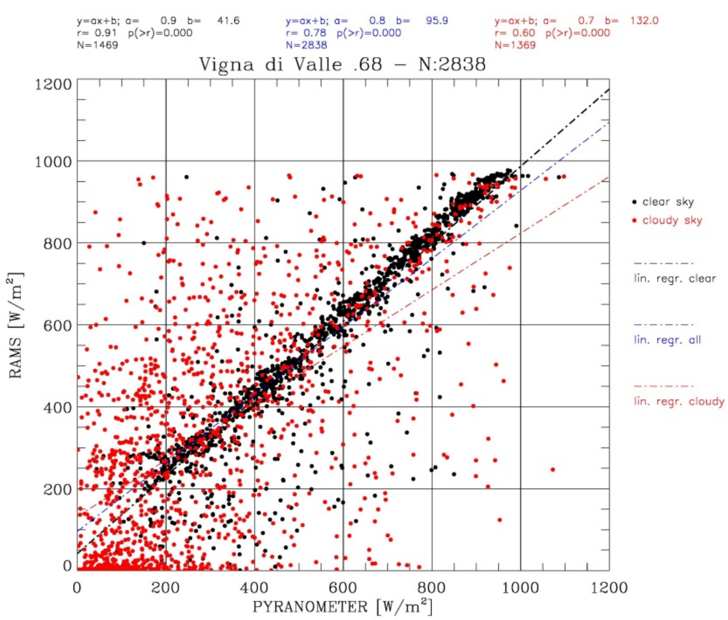
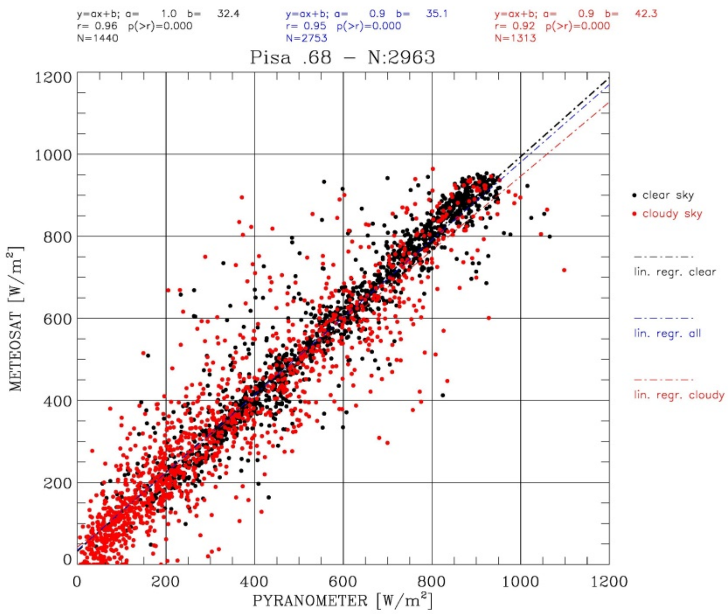


Figure 6 – Vigna di Valle (vdv): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).

a)



b)

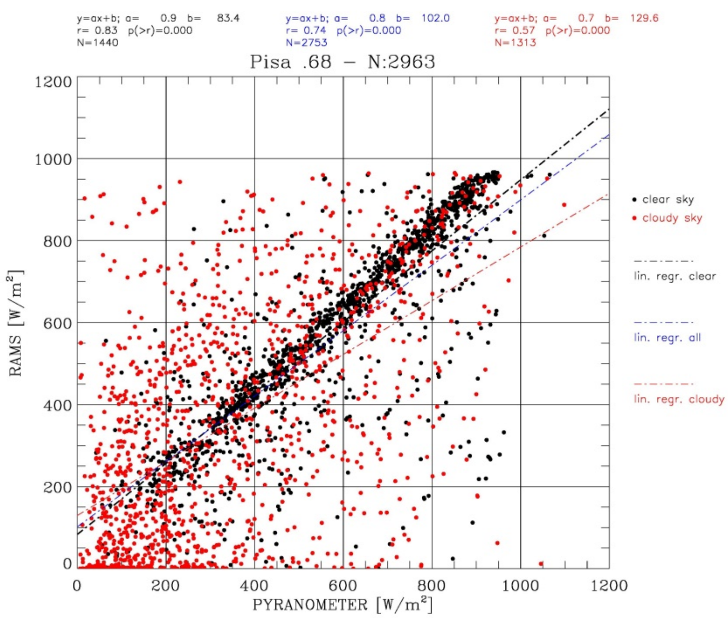
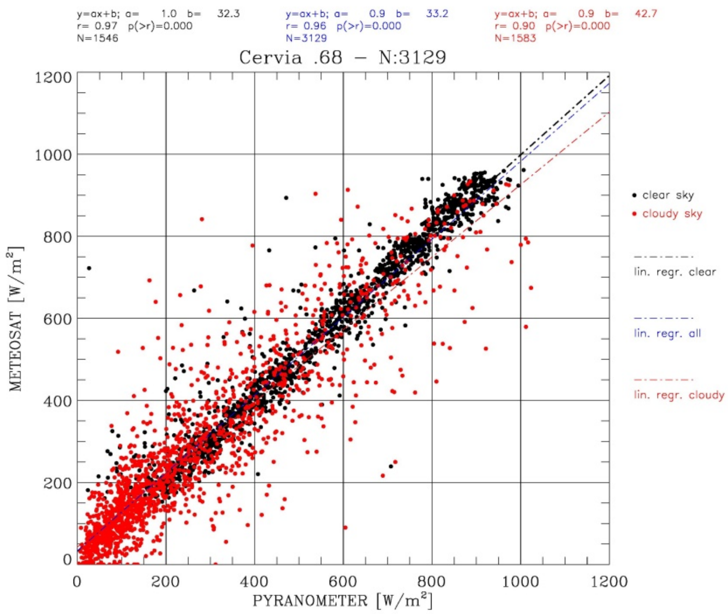


Figure 7 – Pisa (pis): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).

a)



b)

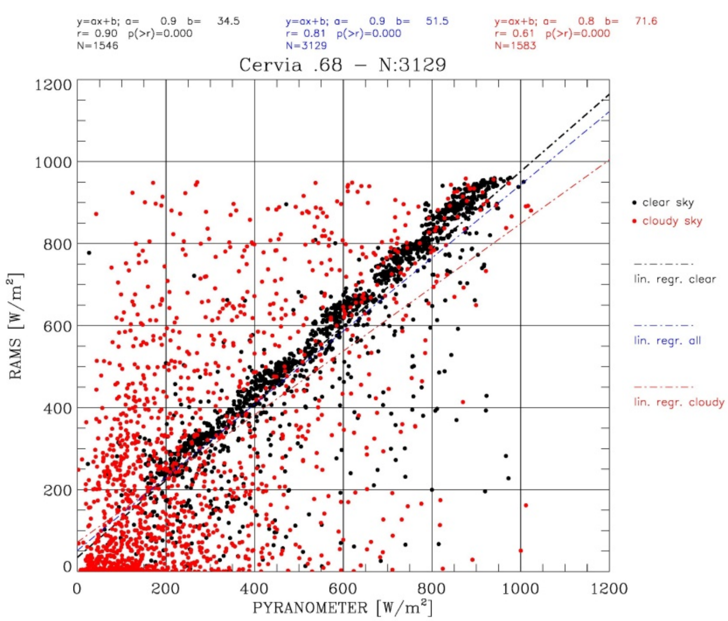
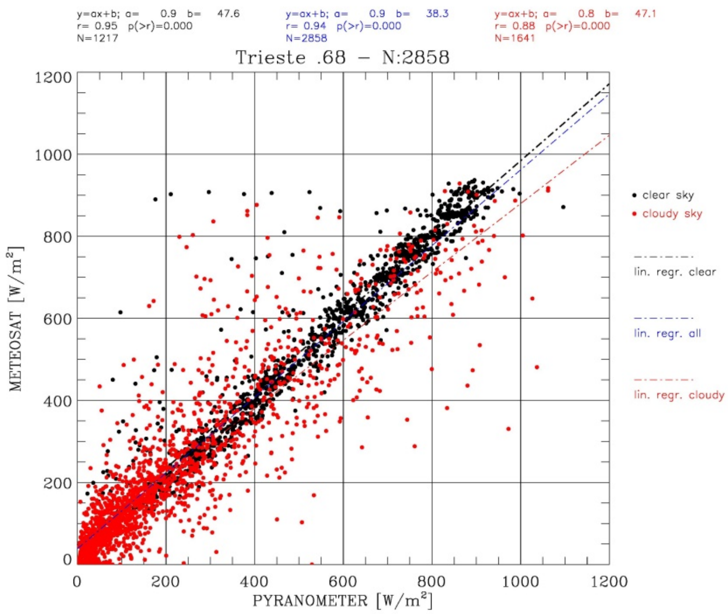


Figure 8 – Cervia (cer): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).

a)



b)

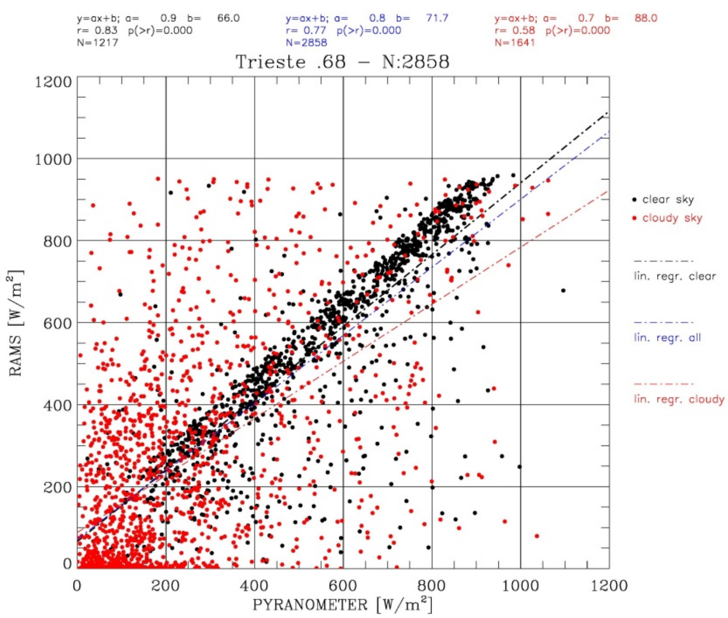
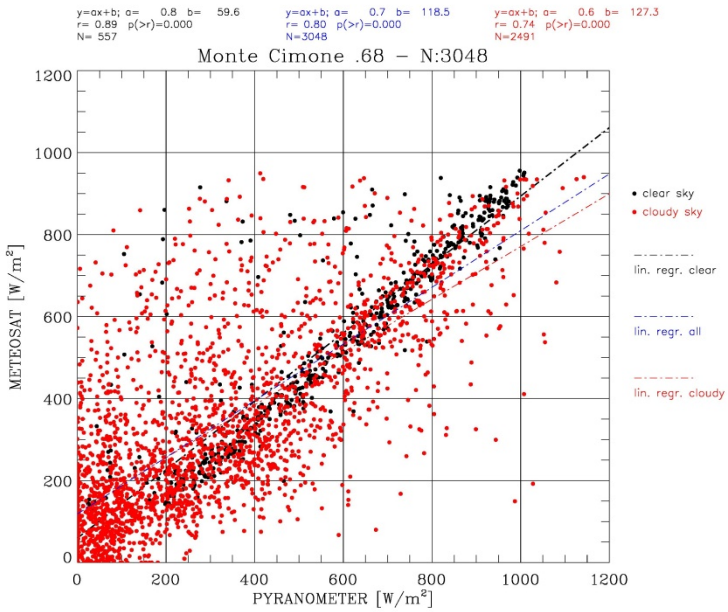


Figure 9 – Trieste (tri): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).

a)



b)

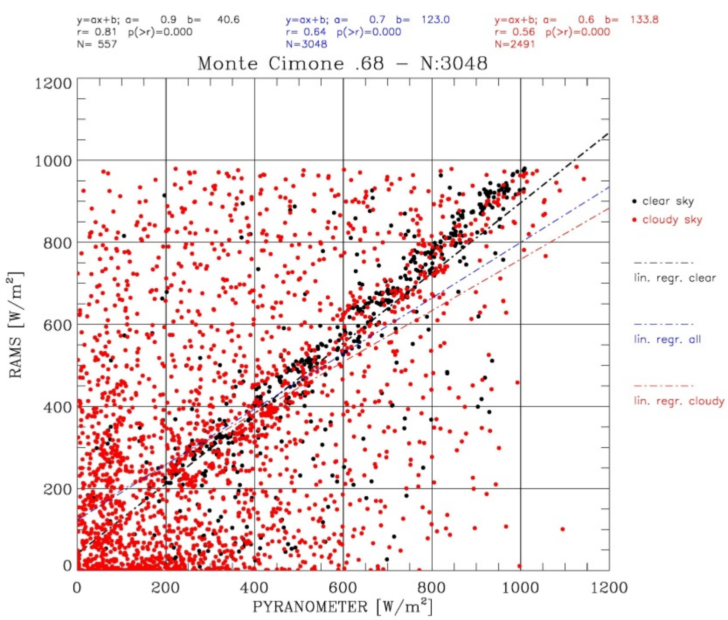
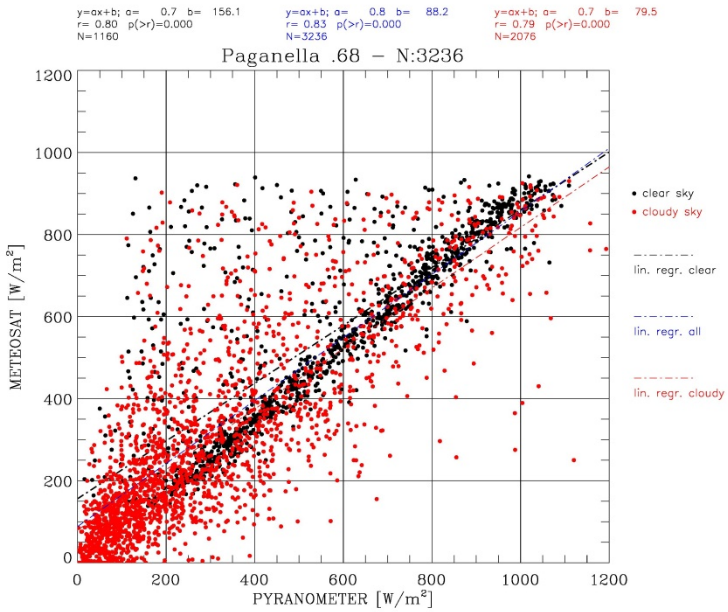


Figure 10 – Monte Cimone (cim): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).

a)



b)

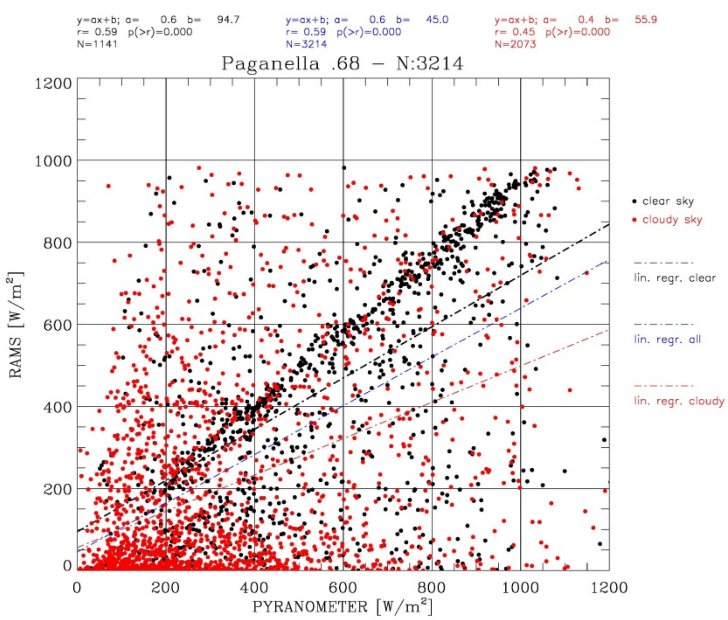
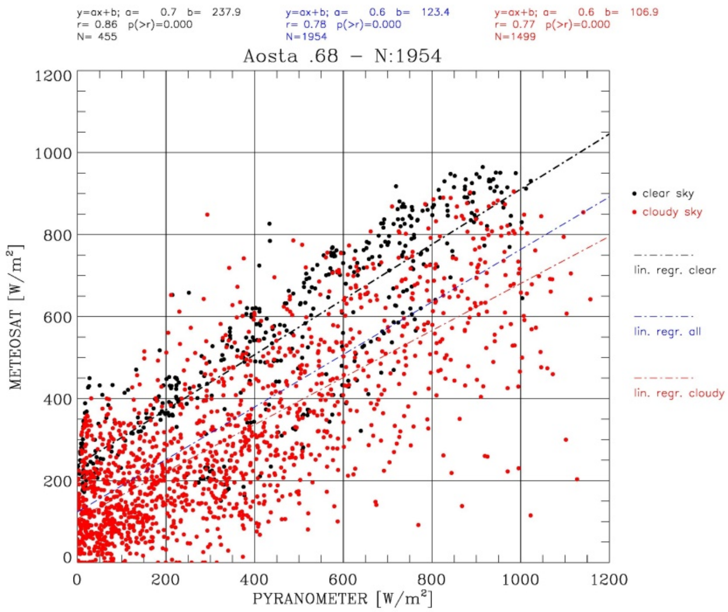


Figure 11 – Paganella (pag): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).

a)



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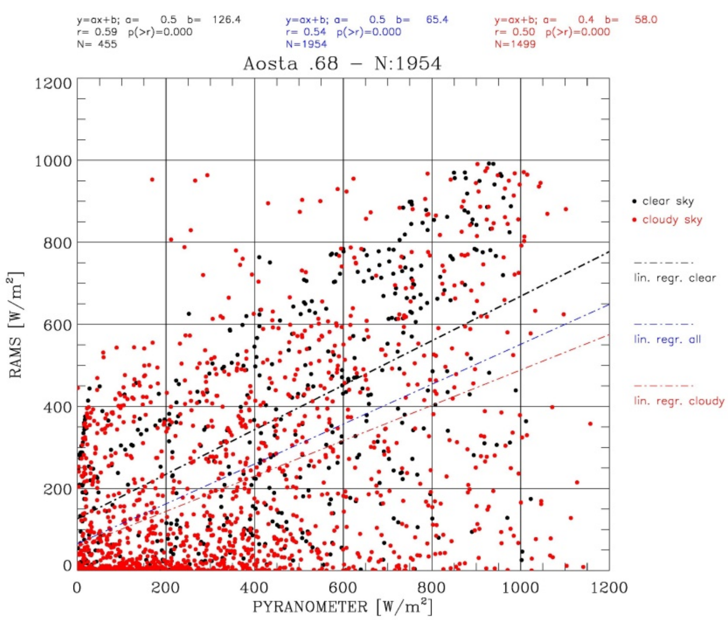

Figure 12 – Aosta (aos): a) scatter plot of the hourly GHI for the pyranometer (x-axis) and MSG (y-axis). The black dots are for clear sky conditions while the red dots are for both contaminated and overcast skies; b) as in a) for the RAMS one-day ahead hourly forecast. Regression lines are shown in their respective colours (blue is for all data, i.e. both clear and cloudy conditions).