The Evaluation of Precipitation Information from Satellites and Models

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Validation activities at CICS/UMD

• Continuation of daily IPWG validation site
  – John Janowiak has retired, JJ Wang taking over operation of site
• Effort has been established to validate NOAA swath data
  – Currently limited to single satellite NOAA products
  – Plan to extend effort to other precip products and snow
• Satellite swaths are matched up with hourly radar data
  – Hourly statistics gathered over 10 day period
Example of swath validation

Correlation

POD (solid), FAR (dotted)

Bias

Bias ratio (rain area)

PDF Comparison

Time-space matched "Swath" Validation Against Radar

Correlation POD

Bias ratio (rain area)

PDF Comparison

0.25 mm THRESHOLD
Evaluation of precipitation from models and satellites

- Need to better validate the hypothesis that models and satellites have *complimentary strengths* which should be exploited in merged precipitation datasets
  - Satellites excellent for convective events, but can struggle with light/shallow rain
  - Models good for large-scale precip, but less good at convective
- Want to demonstrate relative skill of models and satellites over US
  - If satellite and models are merged, what features does each represent well?
- Model data available are from either reanalysis (stable) or operational models (better?)
Sources of data for US study

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<tr>
<th>Name</th>
<th>Type</th>
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<th>Source</th>
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<tbody>
<tr>
<td>CMORPH</td>
<td>Satellite (PMW, IR)</td>
<td>0.25°</td>
<td>NOAA/CPC</td>
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<tr>
<td>TMPA</td>
<td></td>
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<td>NASA/GSFC/TRMM</td>
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<tr>
<td>MERRA</td>
<td>Reanalysis forecast</td>
<td>⅔°× ½°</td>
<td>NASA/GMAO</td>
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<td>Operational Model Forecast</td>
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<td>ECMWF</td>
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Validation period: July 2009 to August 2012 (3 years)
US Validation data

- Validation data: 3-hourly Stage IV gauge corrected radar product (averaged to 0.25°)
  - Also used CPC Unified gauge analysis
- Stage IV has issues over Western US and is less skillful over Rockies
Bias versus CPC daily gauges

- Bias of satellite products fairly well characterized in other studies
- Bias of reanalyses is reasonable
- Operational models can have quite large biases in all seasons
DJF 3-hourly Correlations

- Models tend to have high skill in winter
  - Skill of reanalyses is similar to that of operational models
- Satellite estimates still good over areas less affected by snow
DJF: snow issues for satellites

• Grey line shows snow on ground (from IMS daily product)
  • CMORPH and TMPA have difficulty with snow on ground
    – CMORPH masks more of this out than TMPA
    – Not clear that TMPA feature is very realistic
• MERRA reanalysis is typical of other models and is not affected by the snow: agrees well with Stage IV
DJF: snow issues for satellites

- Again, MERRA quite accurately represents precip over snow
  - Some scale issues due to MERRA resolution
- TMPA screening allows that product to capture the major storm system
  - Amounts may be unrealistic in places
DJF: snow issues for satellites

Downside of less severe TMPA screening: some bogus events occur
JJA 3-hourly Correlations

- Model skill in representing summer sub-daily precipitation is very limited
  - Do not expect good results due to limitations in convective parameterizations
- Models exhibit some skill in North East
- Overall, suggests that models are currently of little use for sub-daily summer precipitation
JJA 3-hourly Correlations

- Representation of summer/convective precip is not realistic in reanalyses
- More complex operational ECMWF model picks up some features
- Satellites capture scale of features very well, as expected
JJA Daily Correlations vs CPC Gauges

- JJA model skill at daily resolution approaching skill of satellites
  - Models may have higher skill over northwest US
- Symptom of how models are validated/calibrated?
  - Summer time diurnal cycle of convective precipitation not well captured
3hrly correlations over US

- Plot shows smoothed 3hrly correlations over time against Stage IV
  - West of Rockies excluded
- Shows clear difference between summer and winter
- Spring and Autumn performance for satellites and models is mixed
What affects model JJA performance?

- Performance in summer is a function of the amount of convective precipitation
  - What about MAM and SON?
MAM 3-hourly Correlations

- Behavior similar to summer
- Models appear to have higher skill over Rockies
  - Could this be due to snow events in March/April?
SON 3-hourly Correlations

- Broadly similar to Spring results
- Models perform very well across US
  - More limited across the south (including Southern Rockies)
3-hourly POD and FAR

Models have more false alarms

With thresh>0, models have high POD
Light rain from models

- Some models predict light rain everywhere...
Light rain from models

... this is not necessarily a problem, but does seem to be mostly erroneous
3-hourly POD and FAR

- With higher threshold, POD is reduced
  - POD and FAR are both quite homogeneously high
- Satellite POD/FAR shows skill in summer
Correlations for non-zero precip

Skill of satellites higher in summer than skill of models in winter

Almost zero correlation for satellites in winter for precip > 0.1 mm hr⁻¹
Precipitation amount

Model skill greatly reduced above moderate threshold

Satellites still good in summer above low threshold
Skill vastly reduced for high threshold
Quantile-Quantile plots

• Want to assess the three-hourly distribution of precipitation
• Use qq plots:
  – Estimate PDF of validation and satellite/model data and plot quantiles
    – 1:1 line is perfect agreement
• Split into 11 geographic regions west of Rockies
Quantile-Quantile plots

cmorph

merra

ecmwf

tmpa

erai

bom
Summary and Further Work

• Models have (+ve) biases in all seasons
  – Operational worse than reanalysis
• Models are unaffected by winter-time surface effects (snow) and can provide considerable skill in these situations
• Models struggle to recreate sub-daily precipitation in summer
• Properties of models reflect difficulty of simulating/forecasting precipitation
  – Issues with precip amount, high POD and FAR
• Would like to extend this to other areas – Europe...
• Explore how to incorporate information into 3-hourly data (CAPE, convective fraction)
  – Incorporate into IMERG, GPCP v3 high-resolution