Method to Decontaminate the Radiometer Wet Tropospheric Correction in Coastal Zones

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Summary

Radiometers, like JMR on Jason-1, measure brightness temperatures (TB) at three frequencies. From this information we derive the total water vapour content, and hence the wet tropospheric correction. The algorithms, however, only apply to open oceans.

In coastal areas the TBs are contaminated by the much brighter and warmer land. Given the footprint size of up to 50 km, this seriously affects the use of altimetry in coastal regions.

Here we attempt to decontaminate the TBs for land effects and then recompute the wet tropospheric correction.

Conclusions

Given the clear linear correlation between brightness temperature and proportion of land in the footprint, we can estimate the TBs for land and ocean (TB_{land}, TB_{ocean}).

These two parameters can be used either to "decontaminate" the observed TB, subtracting $p\,(TB_{land} - TB_{ocean})$, or TB_{ocean} can be used directly as smoothed decontaminated value.

The wet tropospheric path delay computed from the decontaminated TBs runs effectively through small islands and appears to follow coastal dynamic well.

En passant, we have identified an apparent 1-second delay in the TBs on the Jason-1 and Jason-2 products. Also AMR wet tropo correction algorithm needs to be improved.

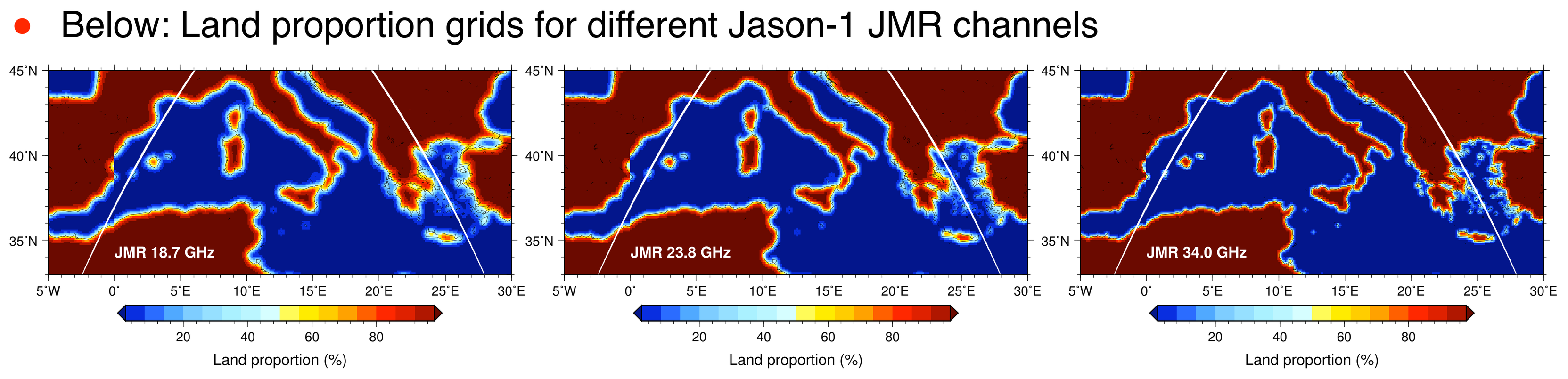
References

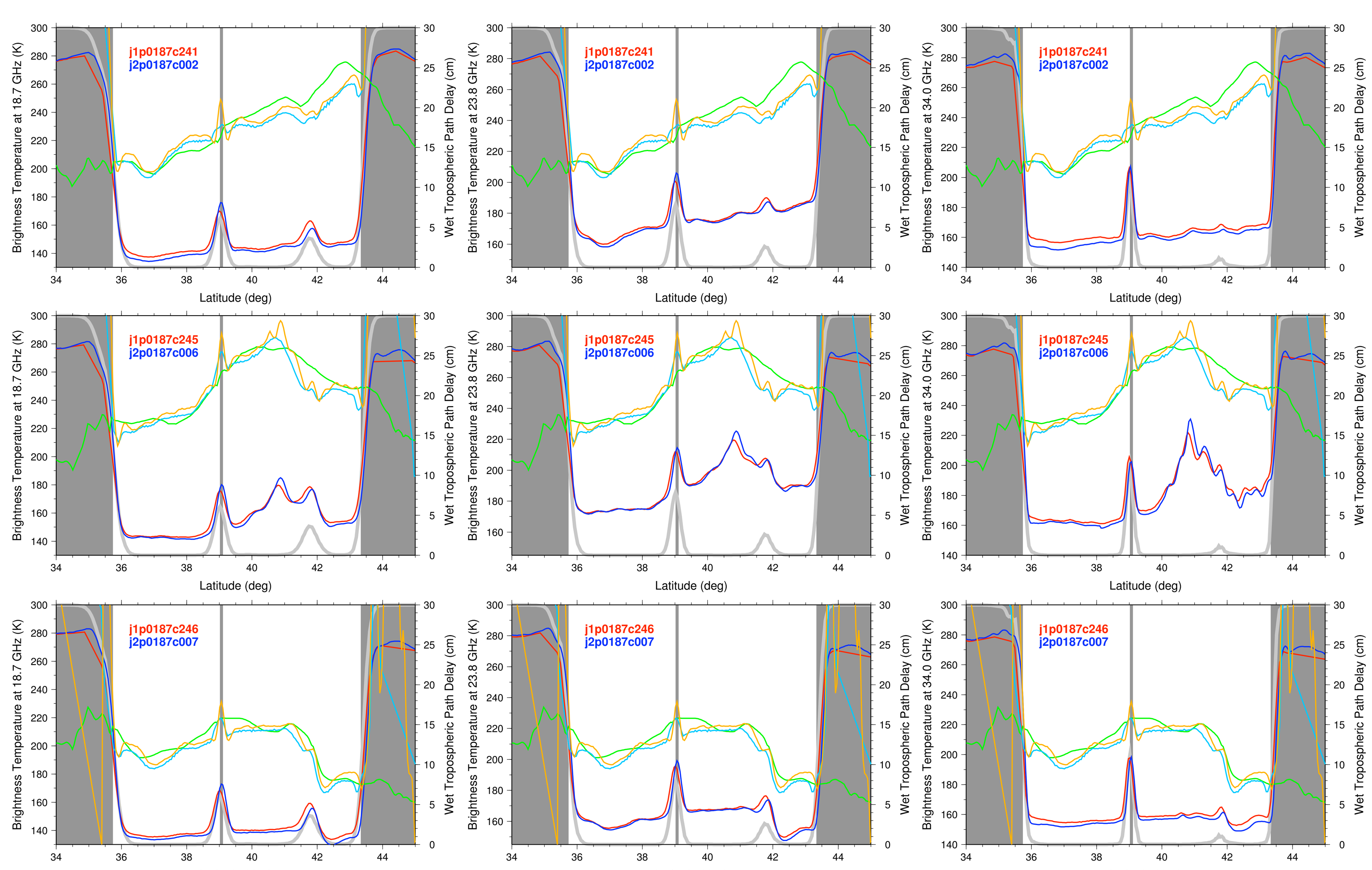
Desportes, C. Quelle correction troposphérique humide pour l'altimétrique côtière et continentale ? PhD thesis, Université Toulouse III - Paul Sabatier, Toulouse, France, 2008.

Desportes, C., E. Obligis, and L. Eymard, On the wet tropospheric correction for altimetry in coastal regions, IEEE Trans. Geosci. Rem. Sens., 45 (7), 2139–2149, doi:10.1109/TGRS.2006.888967, 2007.

Motivation

- TOPEX, Jason-1, and Jason-2 all carry 3-channel microwave radiometers that measure brightness temperatures at 3 distinct frequencies. These frequencies are needed to cancel out or separate the contributions of **water vapour**, **liquid water** and **surface wind**.
- Retrieval algorithms work only over open oceans.
- The lowest frequency channel has the largest footprint (up to 50 km) and is thus affected by land while still quite far from the coast.
- Below: Land proportion grids for different Jason-1 JMR channels

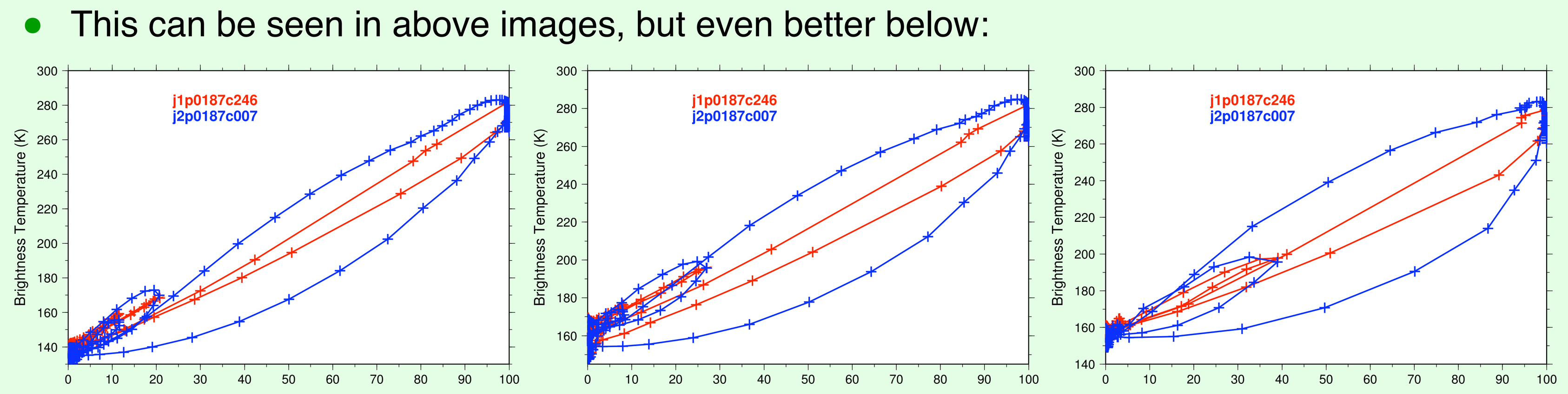




- Above: Brightness temperatures (dark colours) and wet tropospheric correction (light colours) along track 187, passing over Ibiza and scraping the Catalan coast. Land (dark grey) and land proportion in footprint (light grey) is indicated as reference.

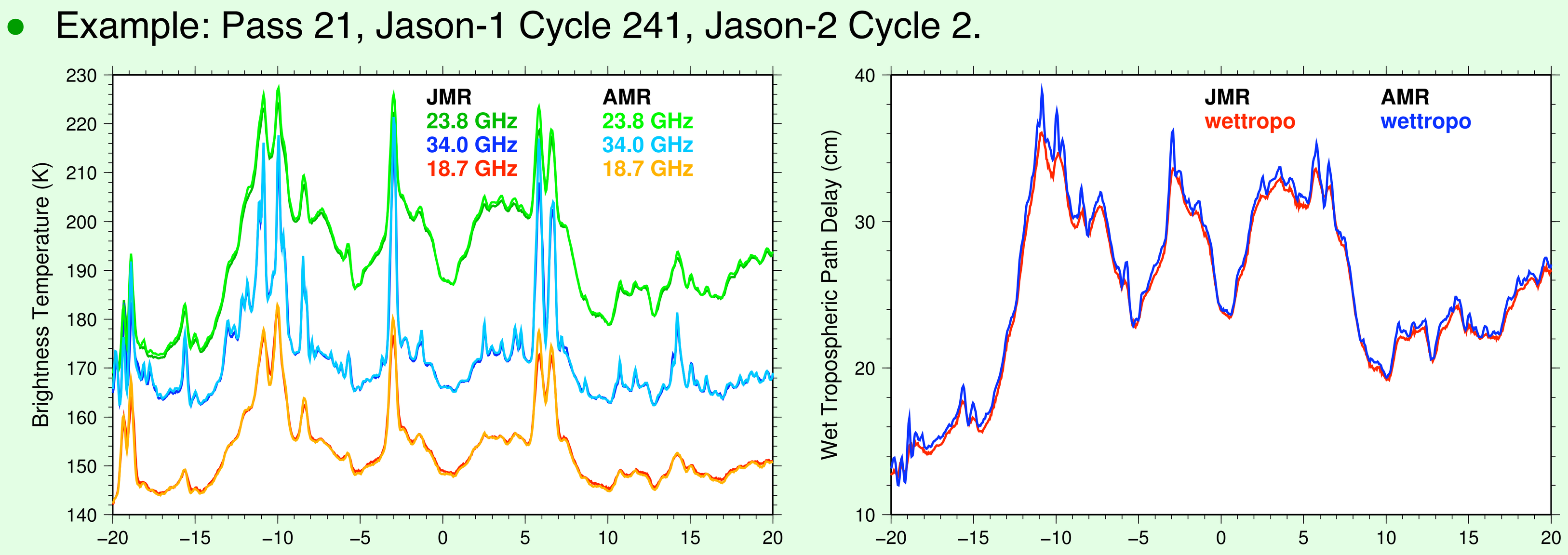
Problems Encountered

- **Problem 1: All JMR/AMR data is shifted by 1-second down track**
- Except during Cycles 241 through 248 when a leap-second was wrongly applied.
- This can be seen in above images, but even better below:



- The Lissajous type curves suggest that there is a phase differences between *p* and *TB*. It is small or negligible for Jason-1 (JMR), but significant for Jason-2 (AMR).
- Otherwise: **Linear dependence between *p* and *TB*.**

- **Problem 2: The AMR TBs have larger peaks and wet tropo more spikes.**
- Example: Pass 21, Jason-1 Cycle 241, Jason-2 Cycle 2.



- AMR wet tropo algorithm needs to be adjusted (currently same as for JMR).

Solutions for Decontamination

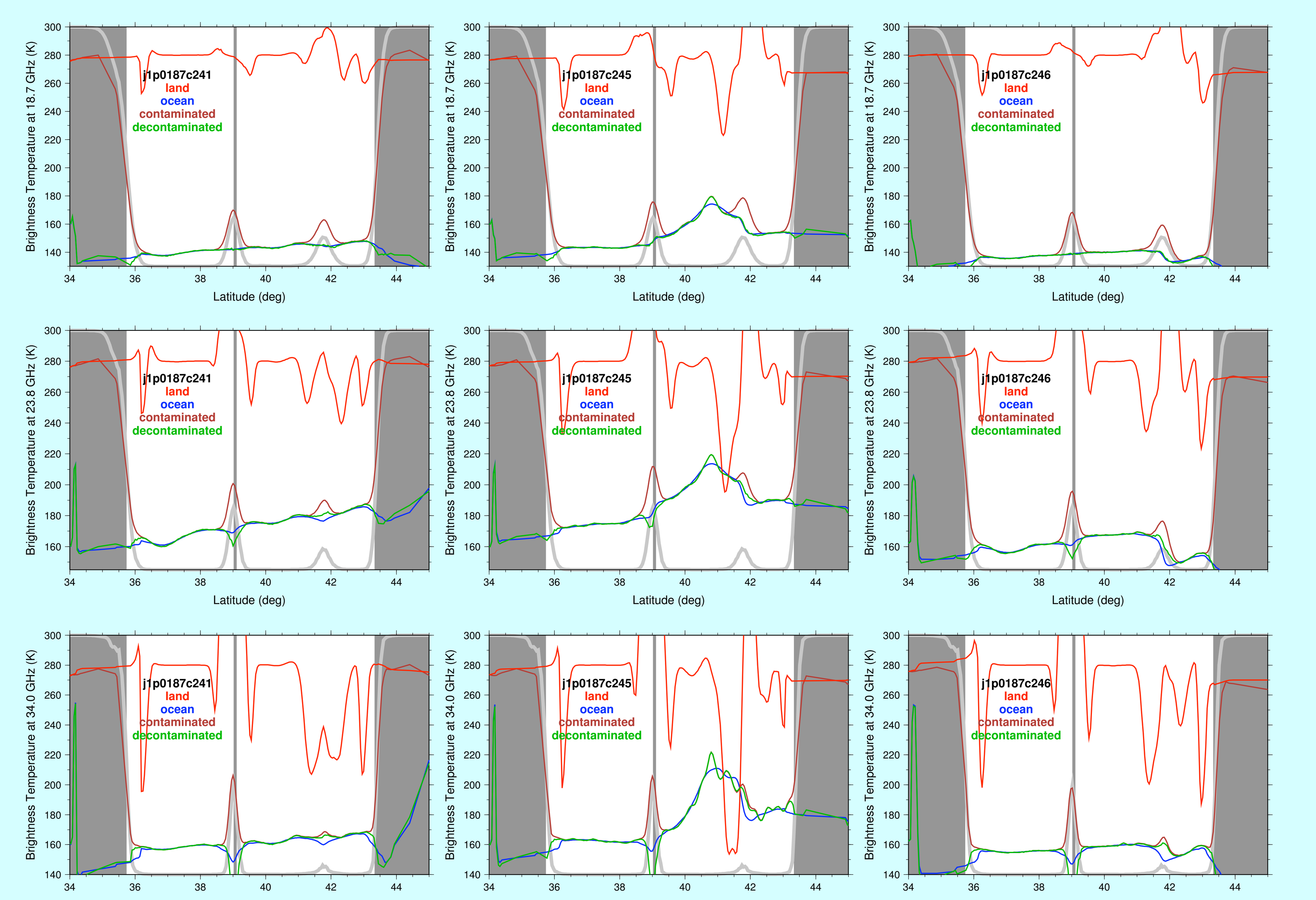
- **Option 1: Interpolate wet tropo correction across islands between closest uncontaminated values. Or propagate last ocean value near continent.**
- Ignores possible coastal effects, particularly when there is a trend.
- **Option 2: Go from radiometer wet tropo to model wet tropo, but offset the latter to match.**
- Avoids discontinuities. Relies on model having the correct coastal dynamic, which it likely does not have.
- **Option 3: Use relation between *p* and *TB* with uncontaminated reference points**

$$TB_{eff} = (1-p)\,TB_{ocean} + p\,TB_{land} \quad \text{or} \quad TB_{ocean} = TB_{eff} - p\,(TB_{land} - TB_{ocean})$$

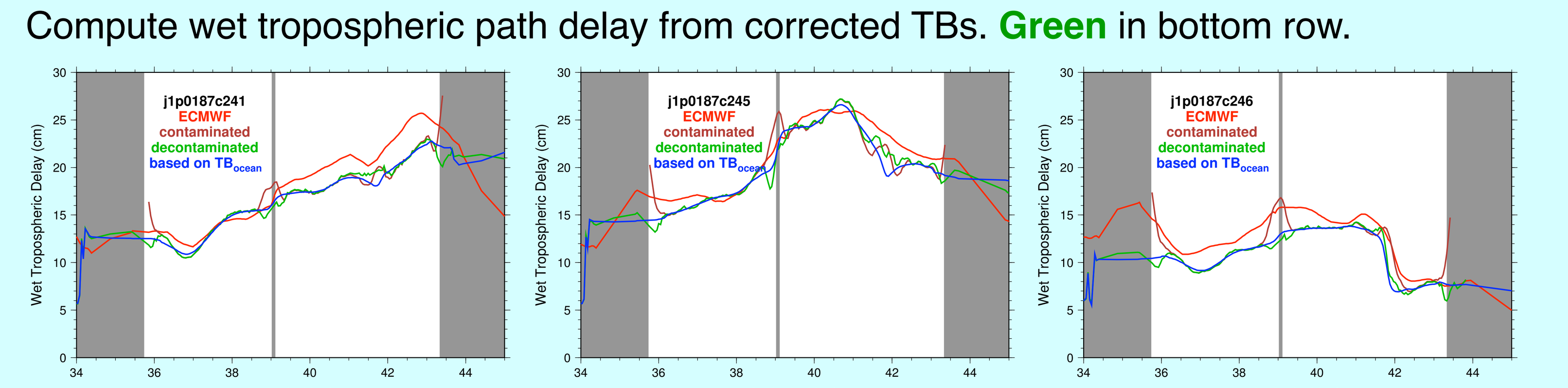
- The last term between () comes from the closest points over ocean (p=0) or land (p=1).
- Problematic over islands (may be too small for p=1), when running tangential to coast, or within archipelagoes (where there may be no p=0).

New Solutions for Decontamination

- **Option 4: Use relation between *p* and *TB* with ($TB_{land} - TB_{ocean}$) based on fit**
- Make linear fit in (p,TB)-space to n data points surrounding each measurement (currently: n=15).
- Use pseudo measurements (0%,160K) and (100%,280K) for constraint.
- Of course, does not produce valid TB_{land} over open ocean or TB_{ocean} over continent, but those values are not needed there.



- Compute wet tropospheric path delay from corrected TBs. **Green** in bottom row.



- **Option 5: Same as above, but use (smoothed) *TB_{ocean}* directly**
- Creates a smoother version of TB_{ocean}, which can be advantageous. **Blue** in bottom row.

Discussion

- Decontamination algorithm does not require any external models.
- Option 4 creates short-wavelength features that were not visible in original wet tropo.
- Option 5 creates smoothed wet tropo correction. n may need to be tuned.
- Both solutions seem to follow coastal dynamic well and create excellent island crossing.
- Tangential pass may still require some attention: there is a "dry spot" in Cycle 246. However, this also appears in the ECMWF model in Cycle 241.
- Open-ocean results are not negatively affected.
- **Need to test this on Jason-2 (AMR) and TOPEX (TMR) as well.**