High Resolution Observations of Coastal Wet Path Delay Variability from the JPL High Altitude MMIC Sounding Radiometer

Shannon Brown

Jet Propulsion Laboratory

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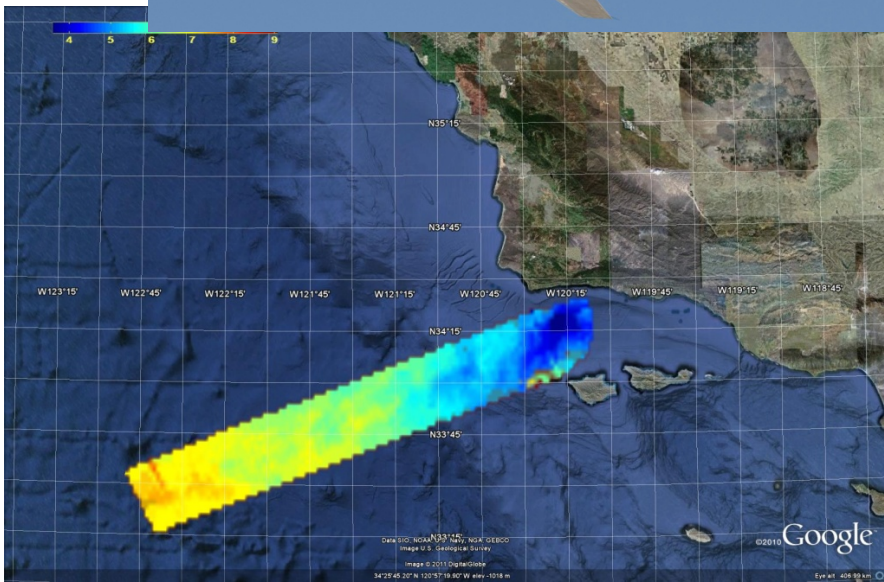
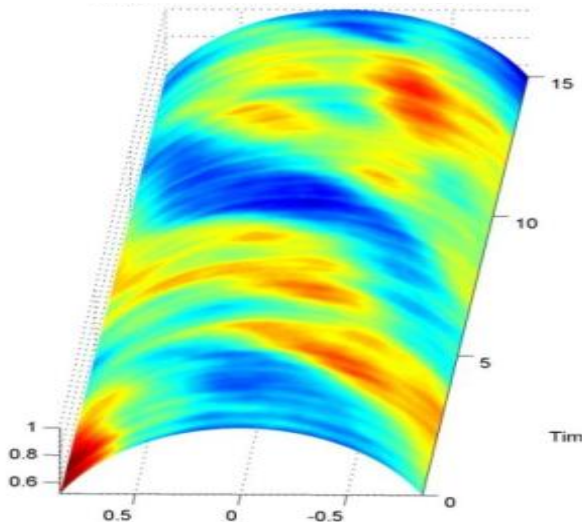
Shannon.T.Brown@jpl.nasa.gov

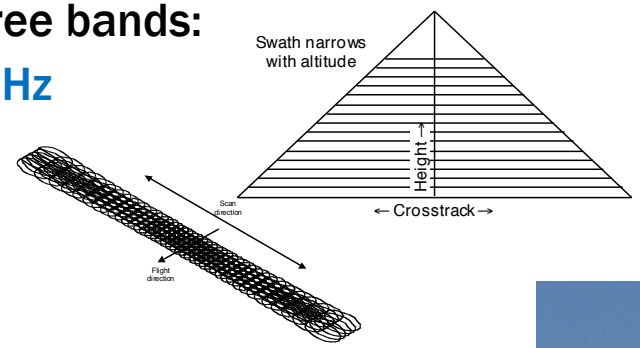




JPL High Altitude MMIC Sounding Radiometer (HAMSR)

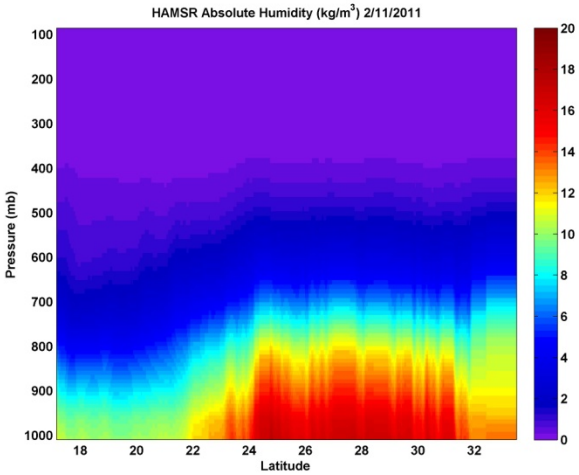
Jet Propulsion Laboratory
California Institute of Technology

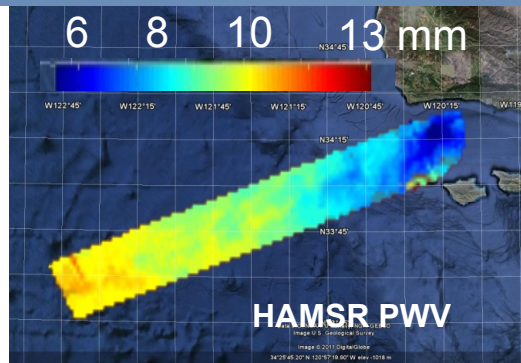
- **JPL High Altitude MMIC Sounding Radiometer (HAMSR)**
  - Microwave radiometer for 3-D all-weather temperature and water vapor sounding, similar to AMSU on NOAA platform
  - Flies on the Global Hawk UAV
  - 25 sounding channels in three bands: 50-60 GHz, 118 GHz, 183 GHz



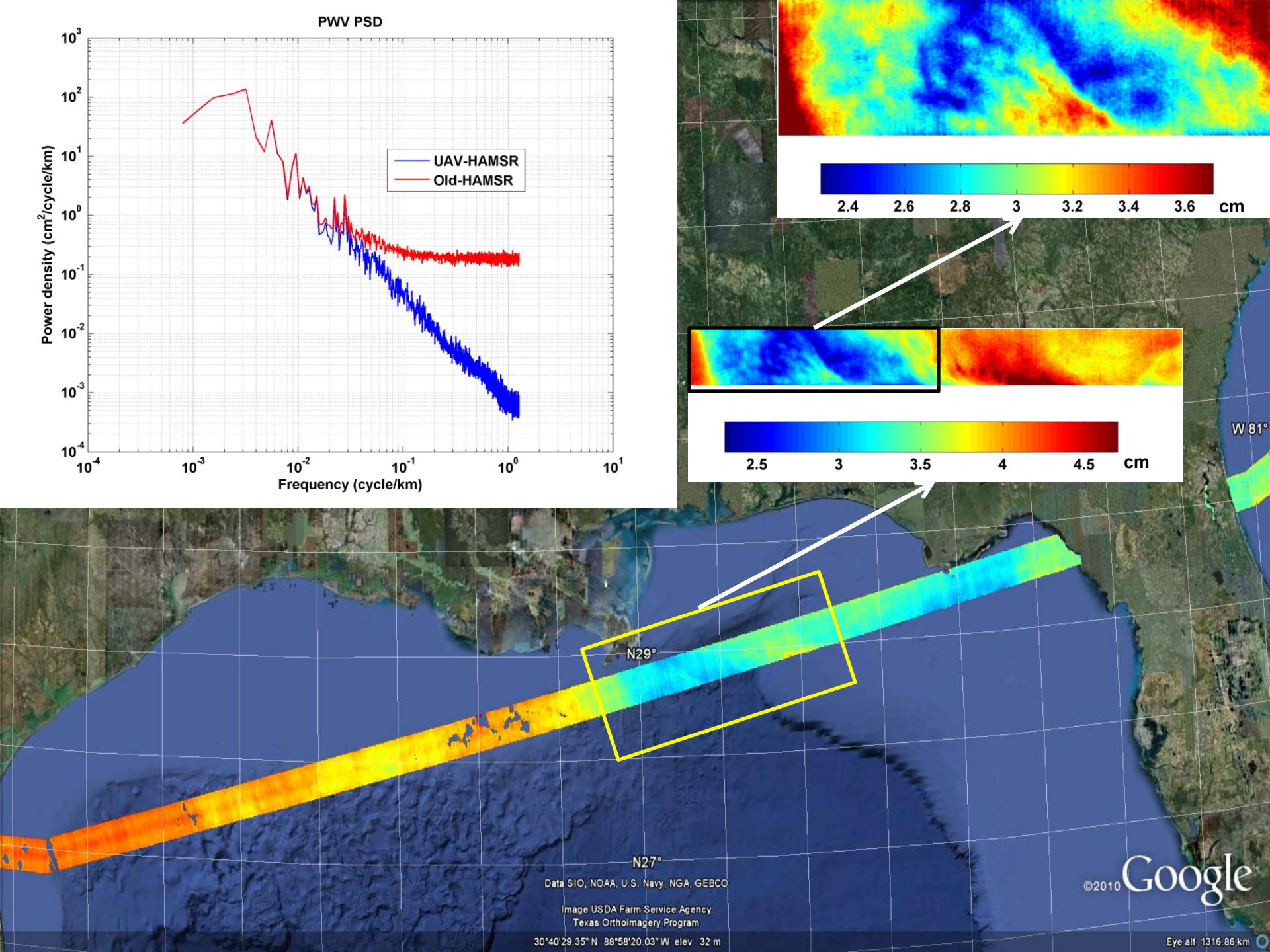
- **Cross track scanning**
  - ± 60° off nadir
  - 65 km swath
  - 1.9 km resolution

- **Recently upgraded with state-of-the art receiver technology enabling observations of small atmospheric structure**





PWV PSD
Power density (cm²/cycle/km)
Frequency (cycle/km)
UAV-HAMSR
Old-HAMSR


2.4
2.6
2.8
3
3.2
3.4
3.6
cm
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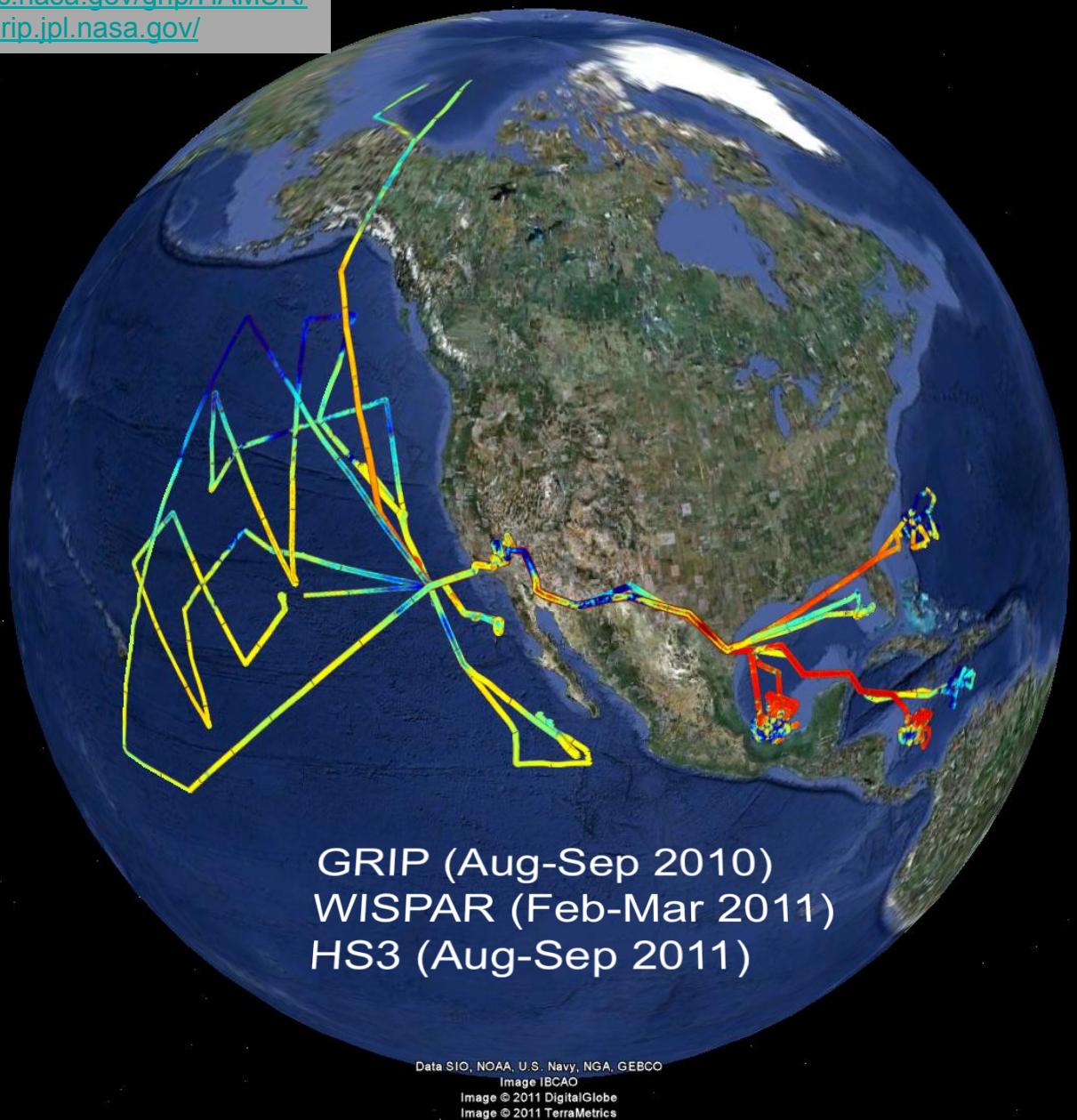
3
3.5
4
4.5
cm
W 81°
N29°
N27°
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image USDA Farm Service Agency
Texas Orthoimagery Program
30°40'29.35" N 88°58'20.03" W elev 32 m
©2010 Google
Eye alt 1316.86 km

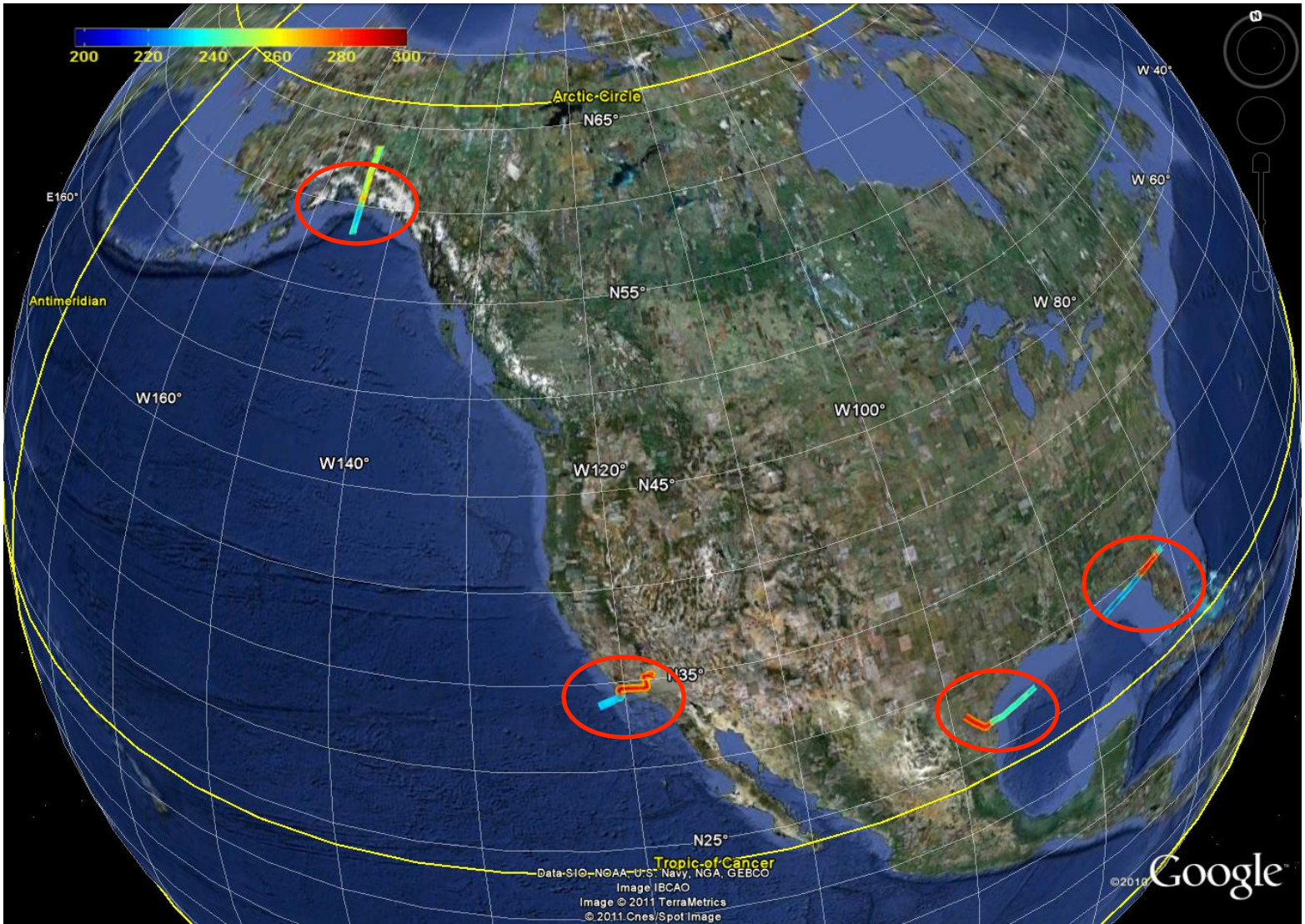
HAMSR Global Hawk Data Sets

L1B files: ftp://grip.nsstc.nasa.gov/grip/HAMSR/
GE quick looks: http://grip.jpl.nasa.gov/



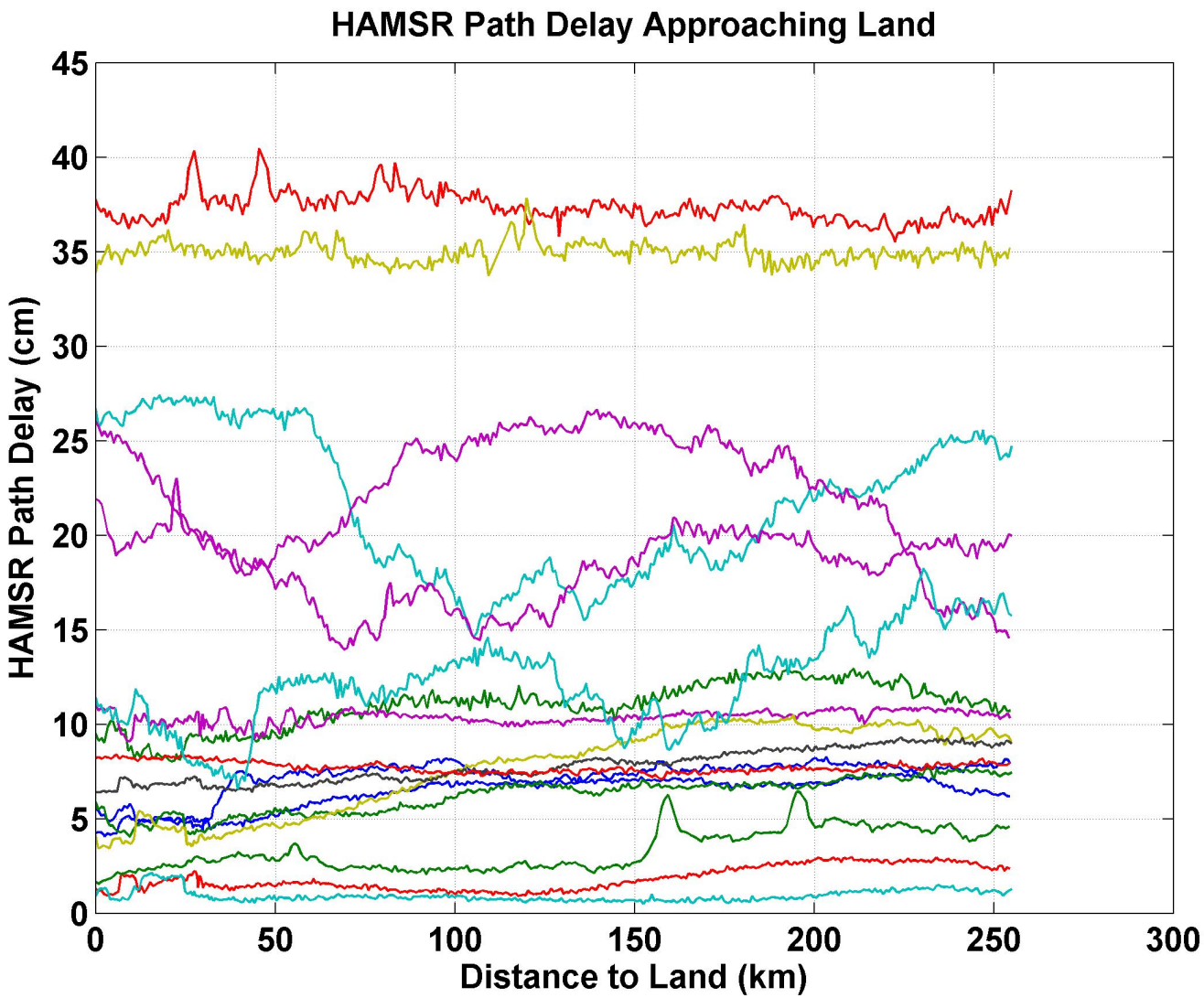
Coastal Path Delay

- **Analyzed 17 coastal crossings over the broad range of PDs**
  - Coastal crossings include southern California, Texas, Florida and Alaska



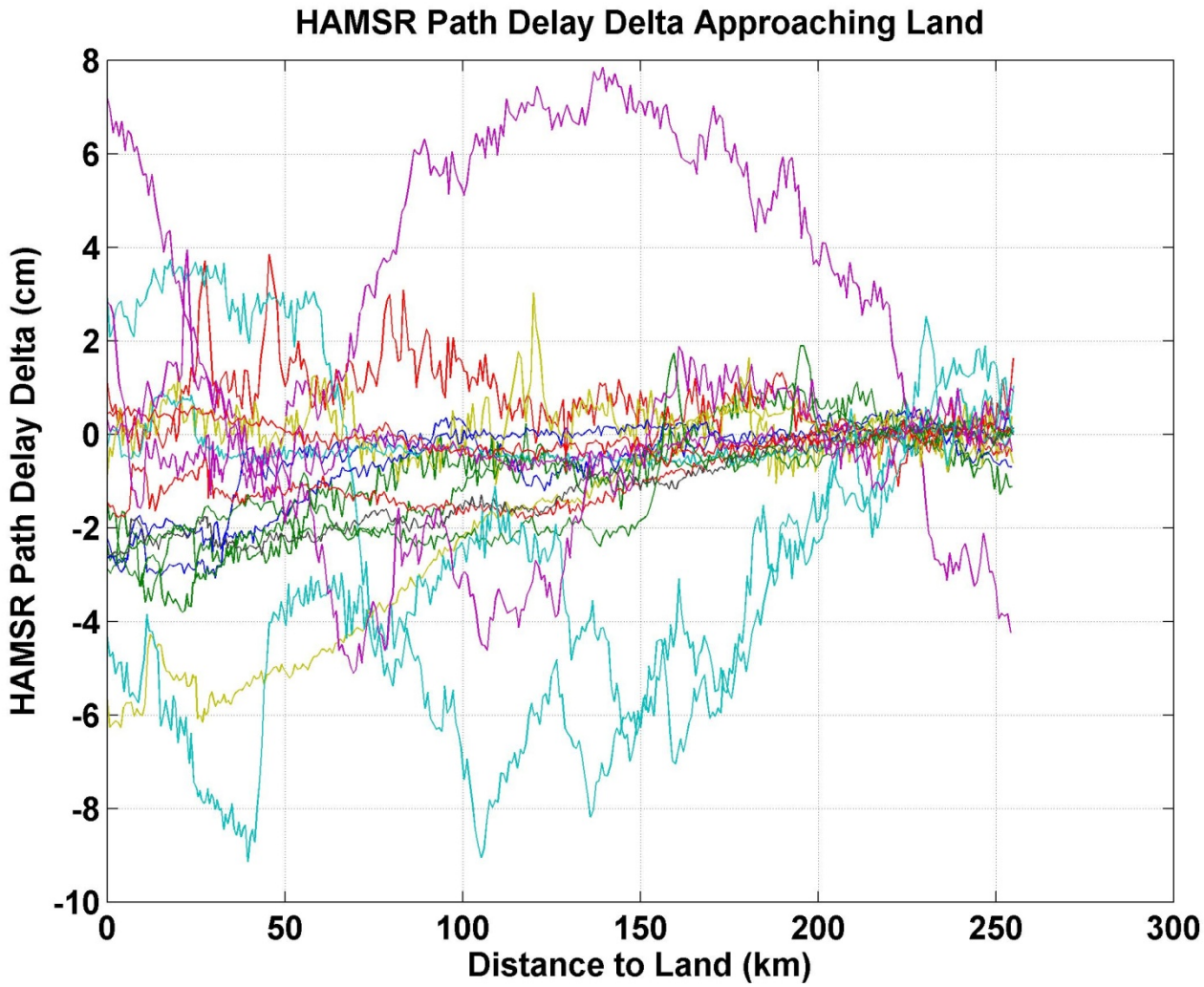
Coastal Path Delay

- PD retrieved using regression algorithm with HAMSR window channels
- Extracted each coastal crossing and analyzed data from 0 to 250 km from land



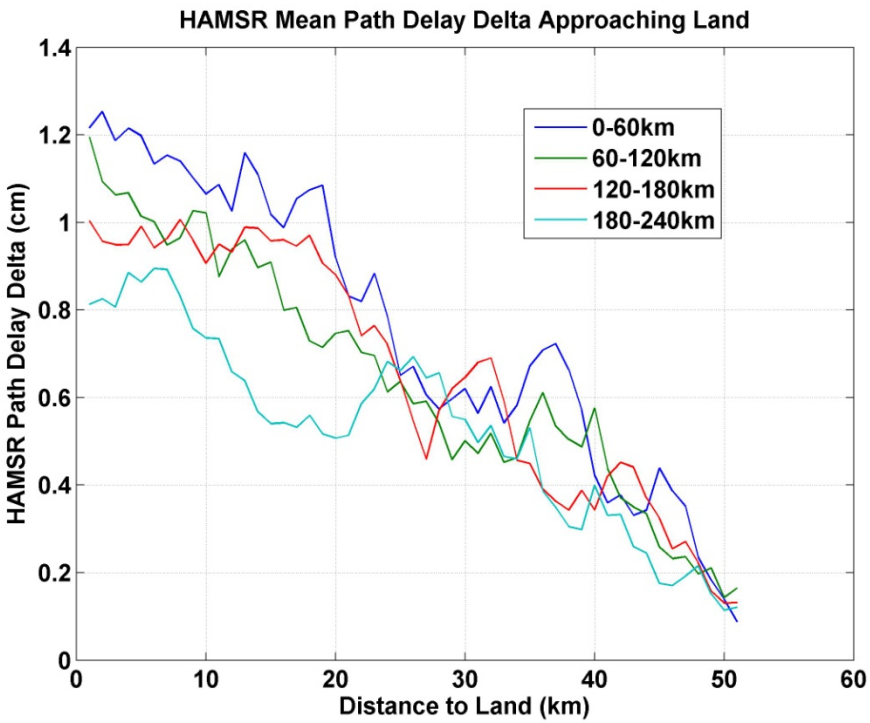
Coastal Path Delay

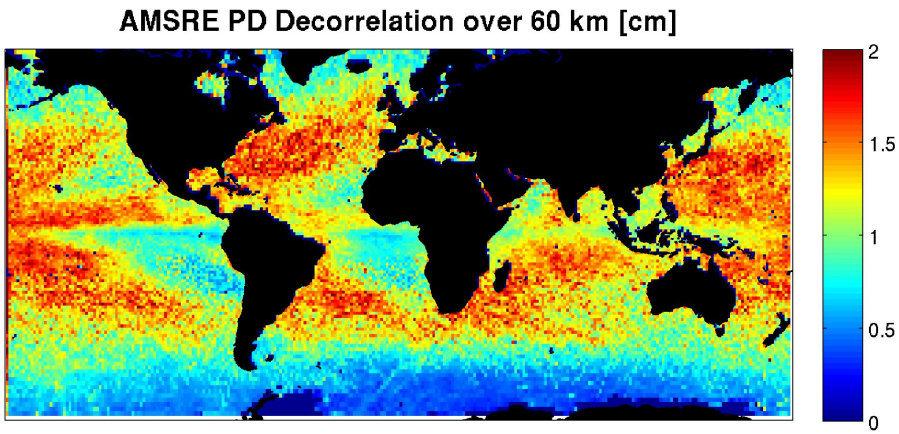
- Differenced each coastal approach from mean PD value between 200-250 km from land
- Large variations observed (up to 9cm), but over all distances and not just near land



Coastal Path Delay Variability

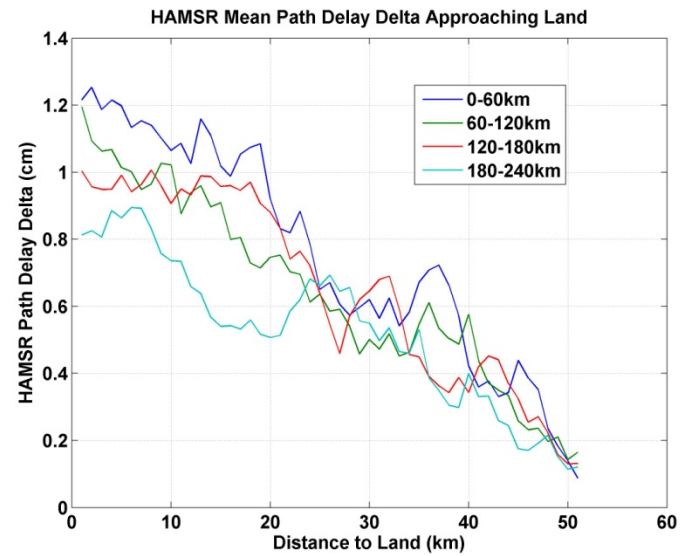
- **Q: How does the variability over the 50 km nearest to land compare with the open ocean?**
- **HAMSR data suggest slightly higher variability near land**
  - Not significantly higher that what is observed in the open ocean
- **Consistent with analysis using WRF PD fields which showed slight enhancement in variability near land**

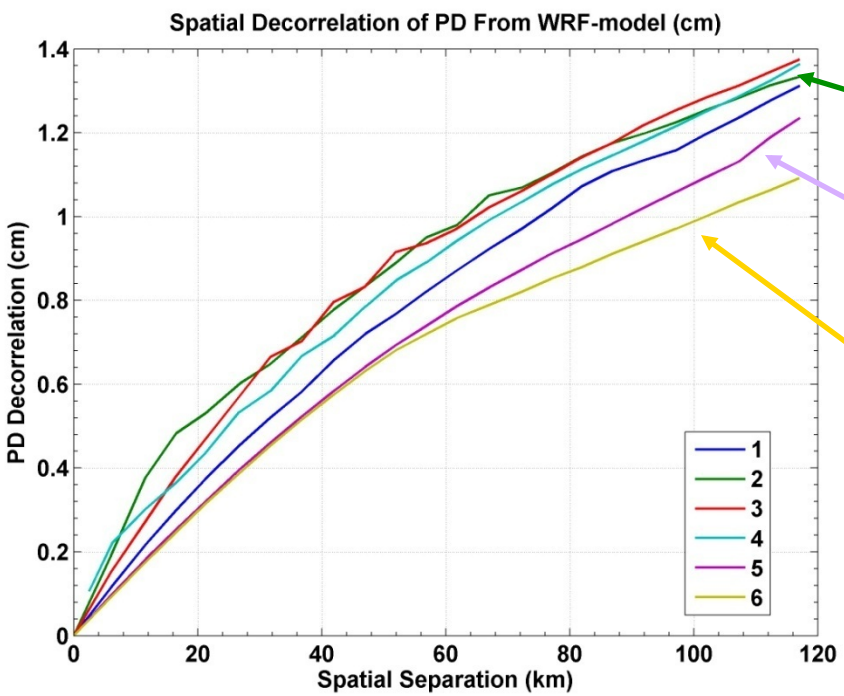




Coastal Variability from WRF

- WRF model shows PD de-correlates over shorter distances near coast consistent with observations
- Larger variability in observations compared to model





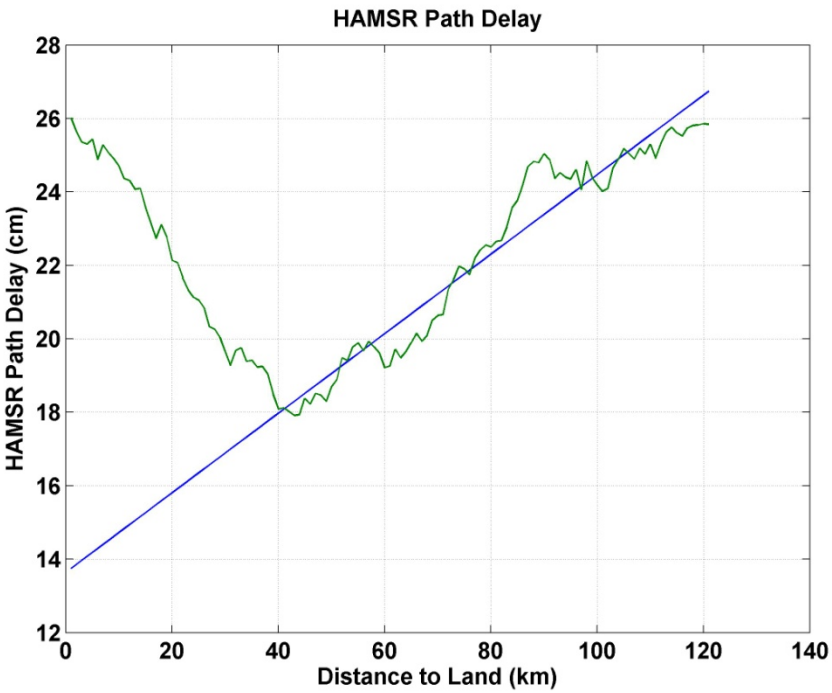
WRF model grid off California Coast

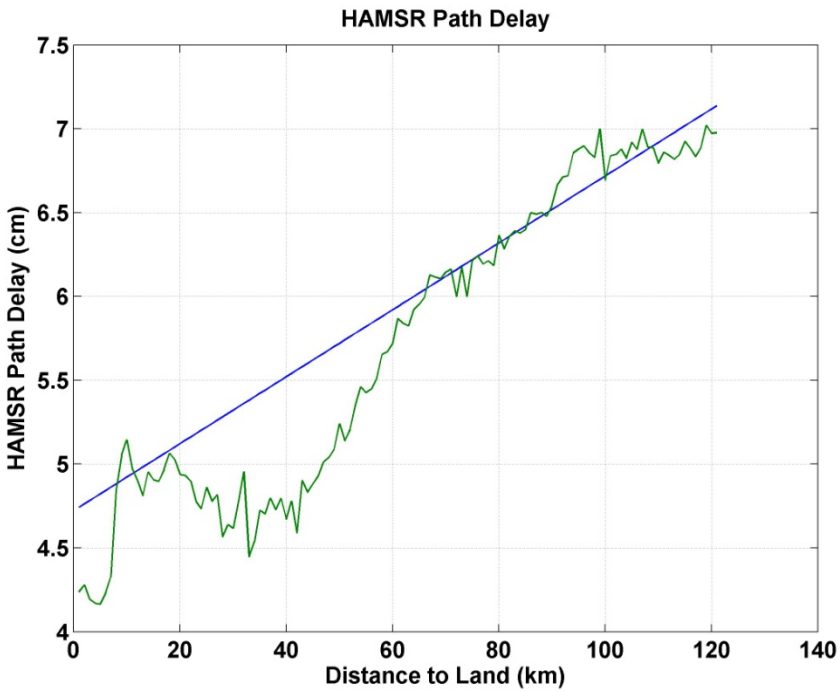
Correction Approaches

- Use last valid open ocean value
- Extrapolate PDs from ocean to the coast
- High resolution model
- High-frequency radiometer
- Coastal correction algorithms for standard radiometers

Extrapolating to Land

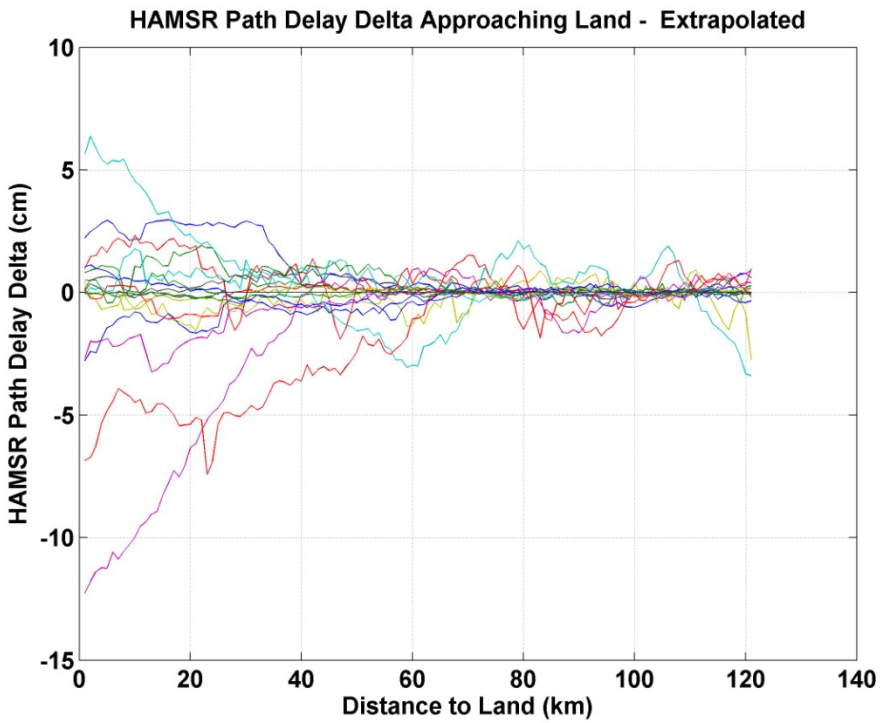
- An approach commonly used is extrapolating the last valid ocean data to the coast
- HAMSR data used to assess errors in this approach

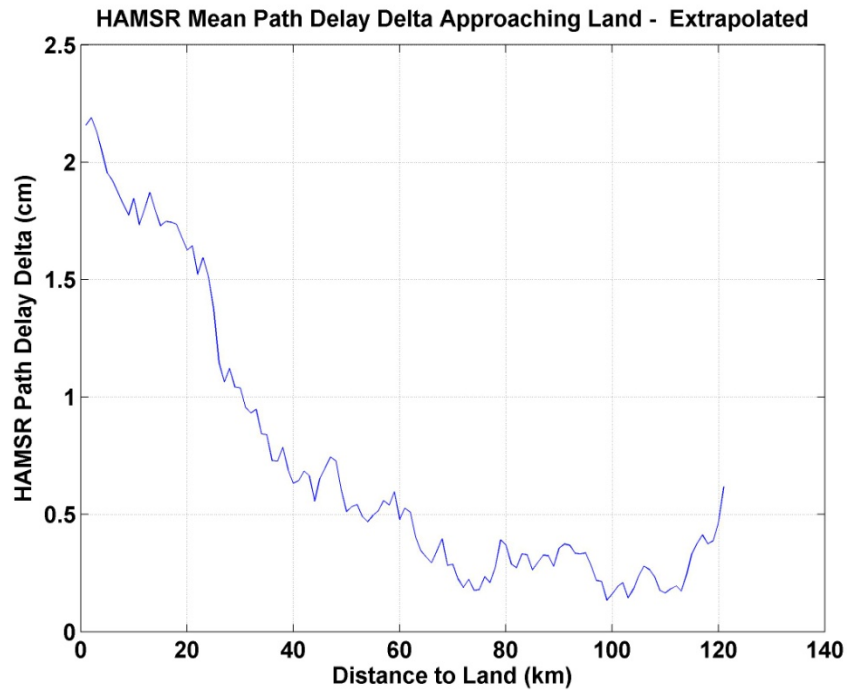




Extrapolation Errors

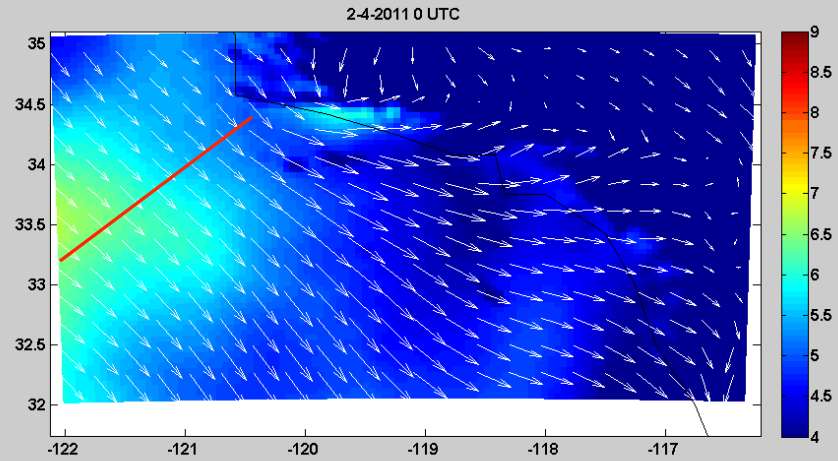
- Extrapolating did not offer improvement and in some cases increased the errors dramatically
- Only a small number of cases analyzed, but using last valid ocean value appears to be as good as or better than extrapolating from open ocean data

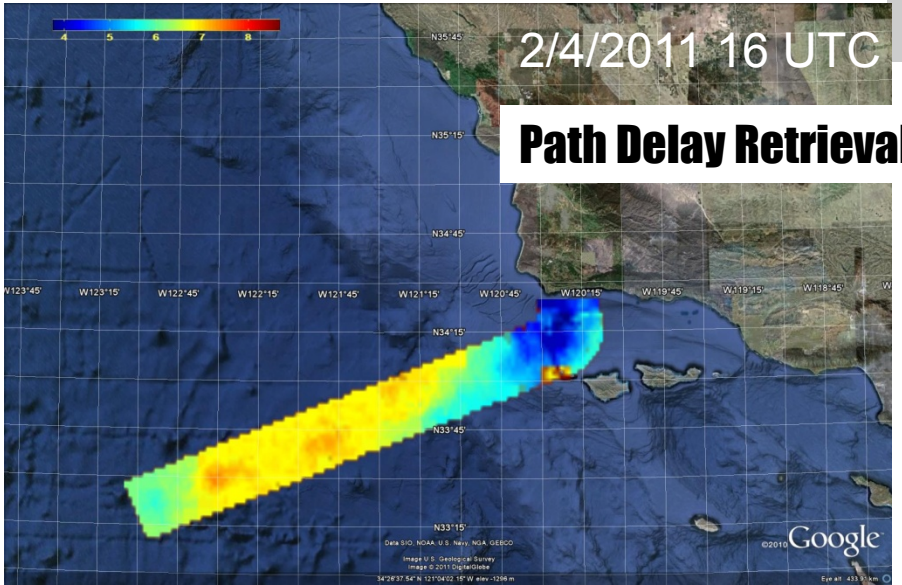




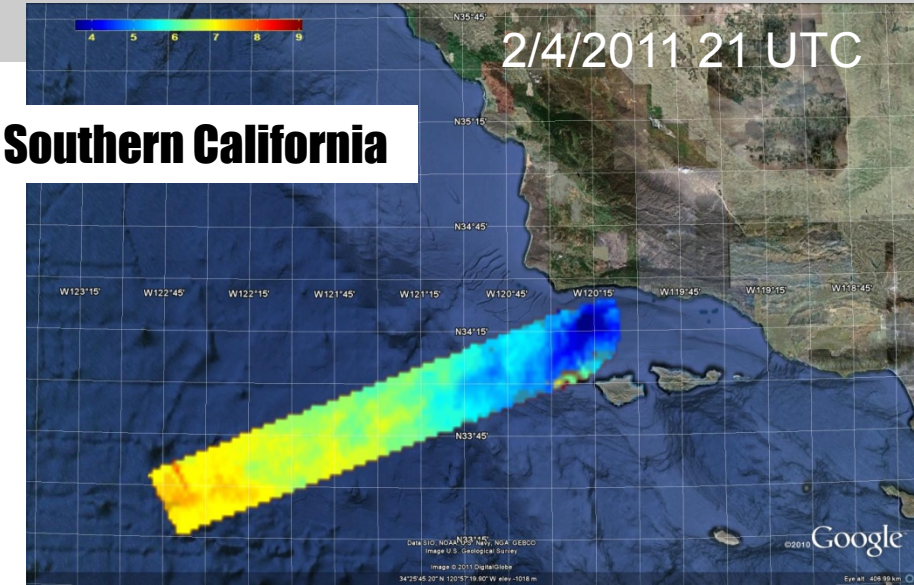
Comparisons to 3-km WRF

- 3-km WRF model outputs provided by Y. Chao for Southern California coastal region
- WRF outputs compared to HAMSR on two flight days

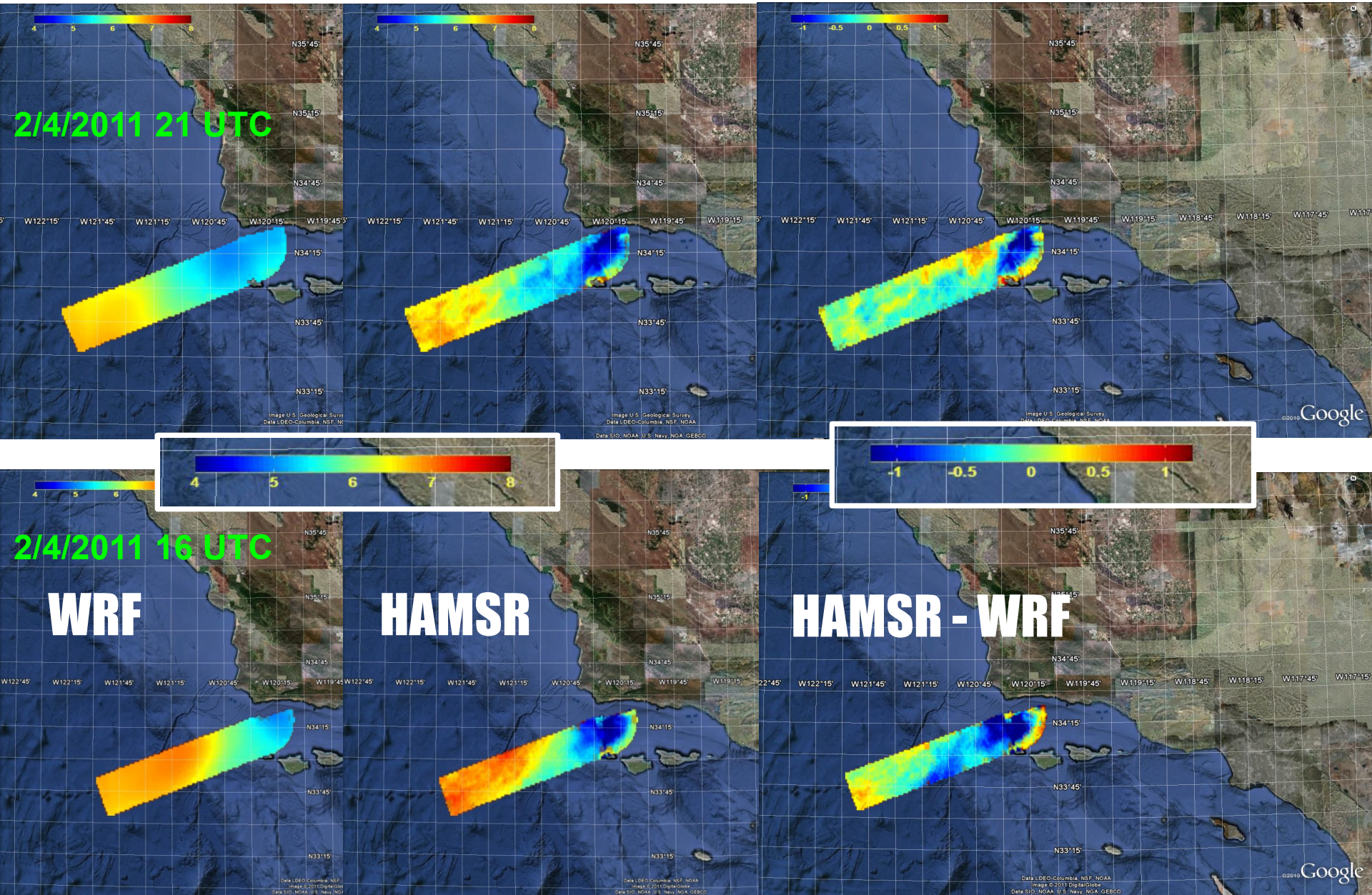




Path Delay Retrieval off Southern California

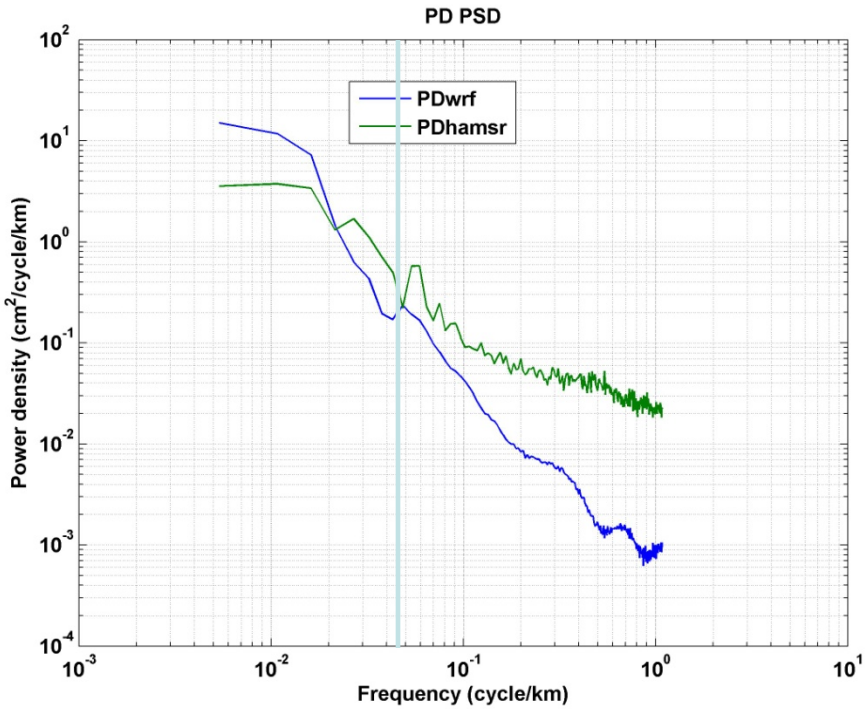


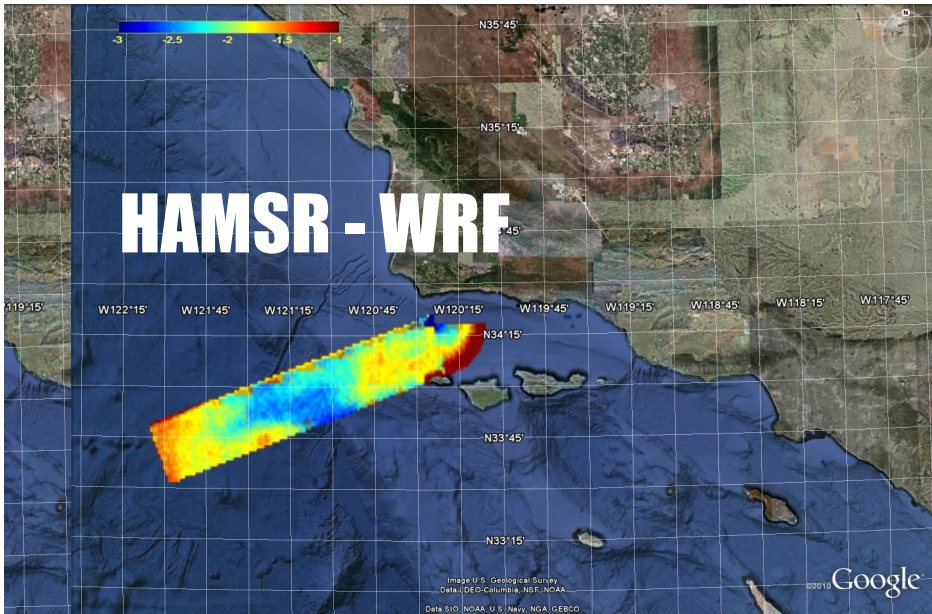
Comparison to WRF

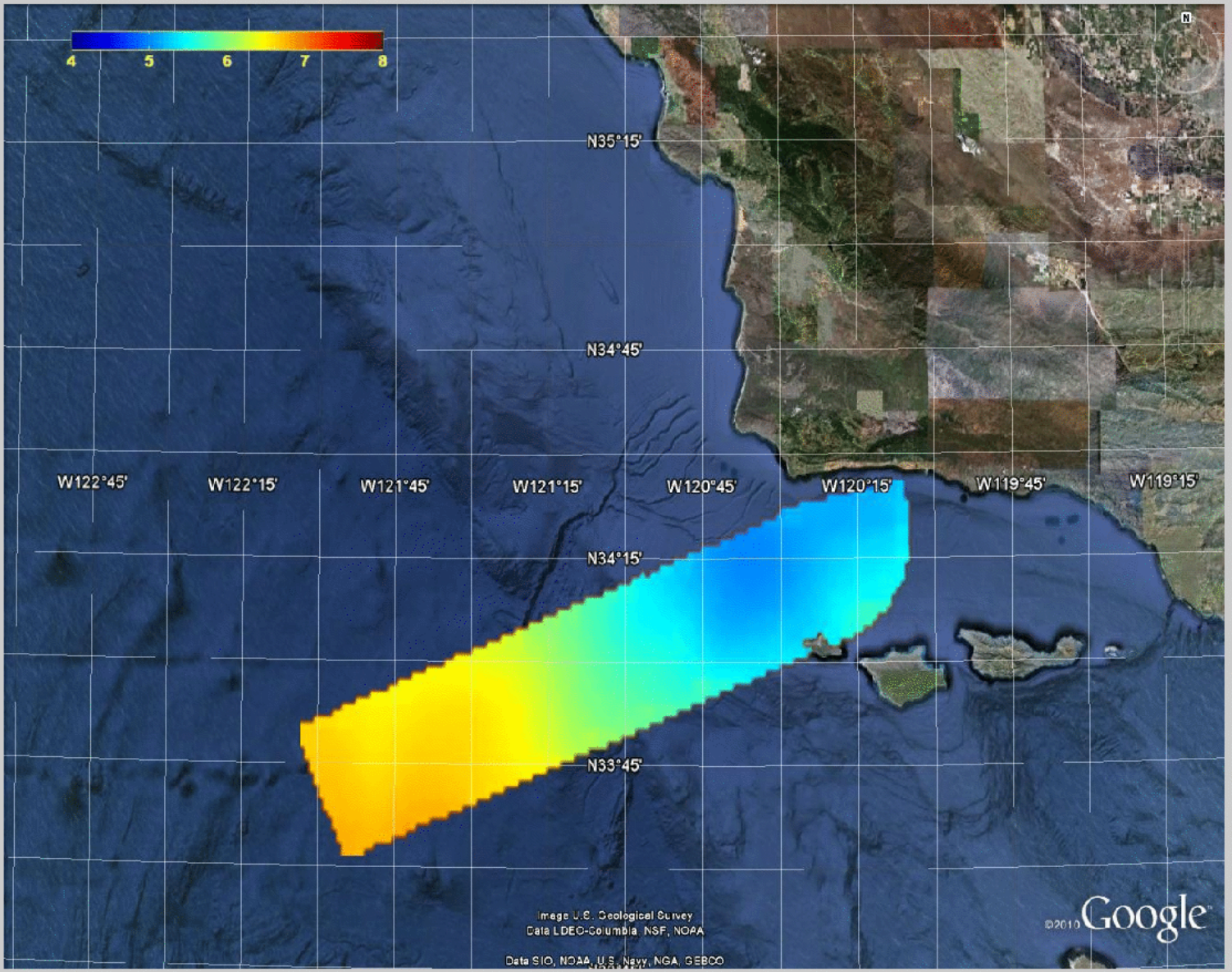


Comparison to WRF

- Of the few cases analyzed, free-running high resolution models show good agreement in some cases, but significant differences in other cases compared to the observations
- In all cases, the actual model resolution was significantly coarser than the reporting grid size
- Skamarock et al., estimate true model resolution is about 7x grid size



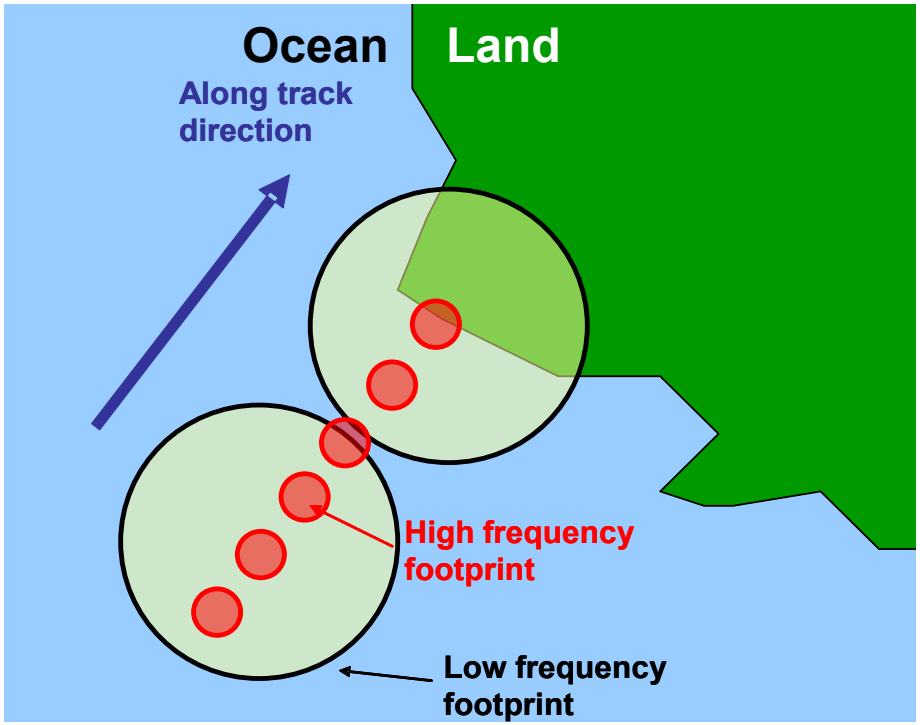




Comparison between HAMSR and WRF PD Fields

High-Frequency Radiometer for Coastal Retrievals

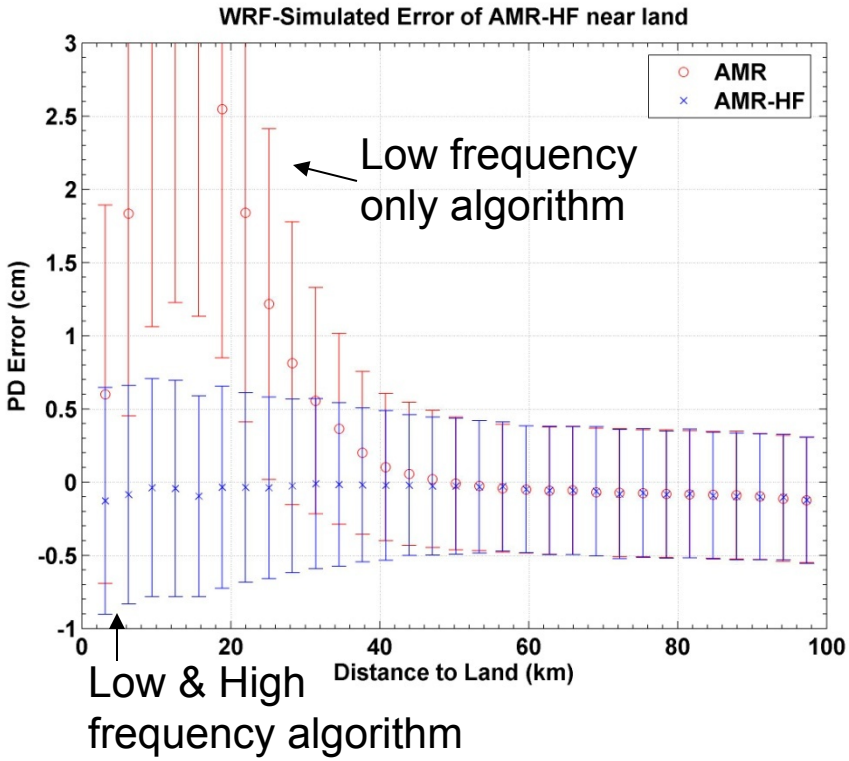
- Channels between 90-160 GHz sensitive to water vapor continuum
- Also sensitive more sensitive to cloud liquid water and water vapor scale height
- Hybrid concept developed to use high-frequency channels near land with a dynamically trained retrieval algorithm

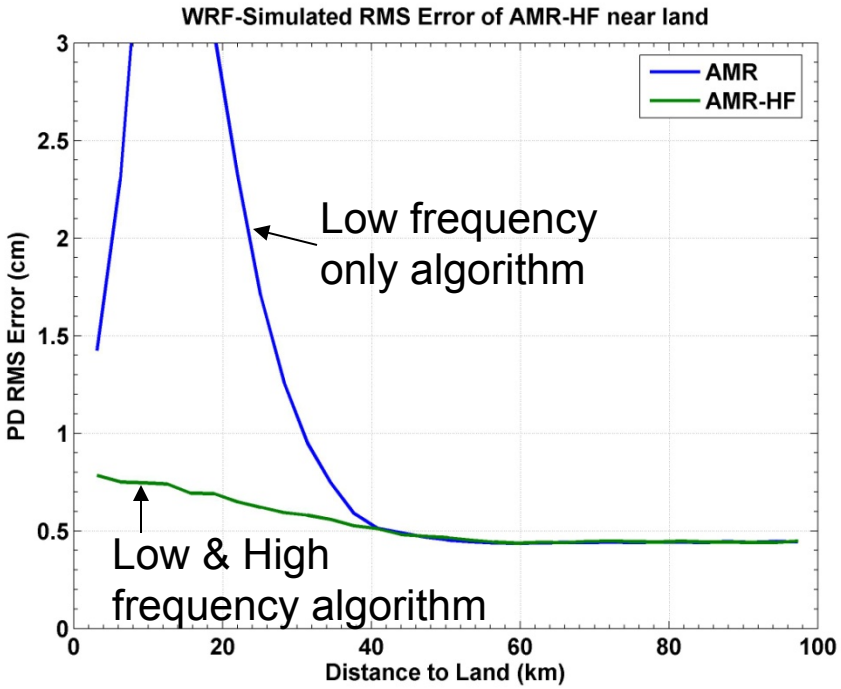


- Standard low-frequency channels (18-34 GHz) used for PD retrieval in open ocean (> 30 km from land)
- High-frequency window channels, 90, 130 and 166 GHz used to continue PD measurement to ~3km from land

High-frequency Coastal Performance

- Simple hybrid algorithm developed and applied to simulated TBs
- Simulated PD retrieval error < 7mm to within 3 km from coast





Summary

- Water vapor variability slightly higher in coastal region compared to the open ocean
  - Observed in models and observations
  - Although, not significantly higher than that observed in other parts of the open ocean
- Comparison of observations to WRF show model resolution is about 7x coarser than reporting grid
  - Consistent with previous studies
- Extrapolating to the coast doesn't appear to be superior to using last valid value
  - Caveat: only small number of cases analyzed
- Combined low/high frequency radiometer appears best method to reduce errors near land