HIWRAP observations from the HS3 campaign: Comparing retrieval techniques

Anthony C. Didlake, Jr., Gerald Heymsfield, Lin Tian, Stephen Guimond

March 5, 2014

68th Interdepartmental Hurricane Conference

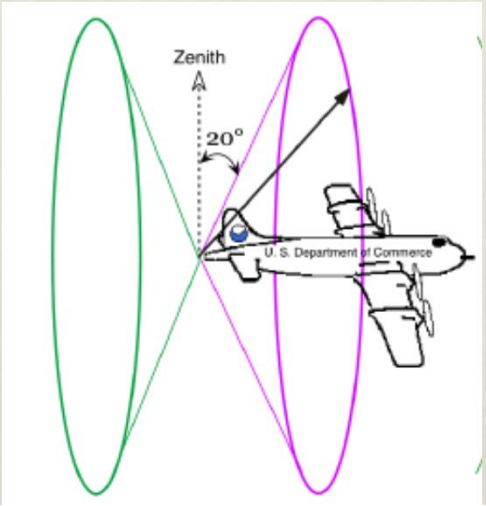
Dual-Doppler retrieval techniques

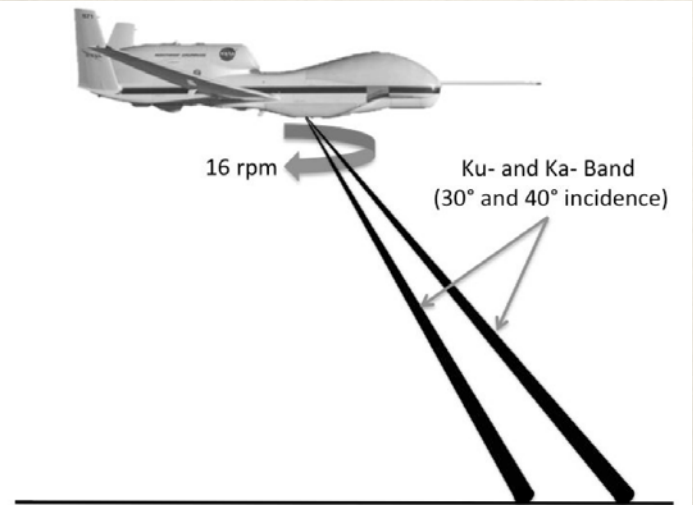
Interpolation and Integration

- Jorgensen et al. 1983, Marks and Houze 1984
- Horizontal wind calculated from radar observations
- Vertical wind retrieved from integration
- Local solver

Cost function optimization

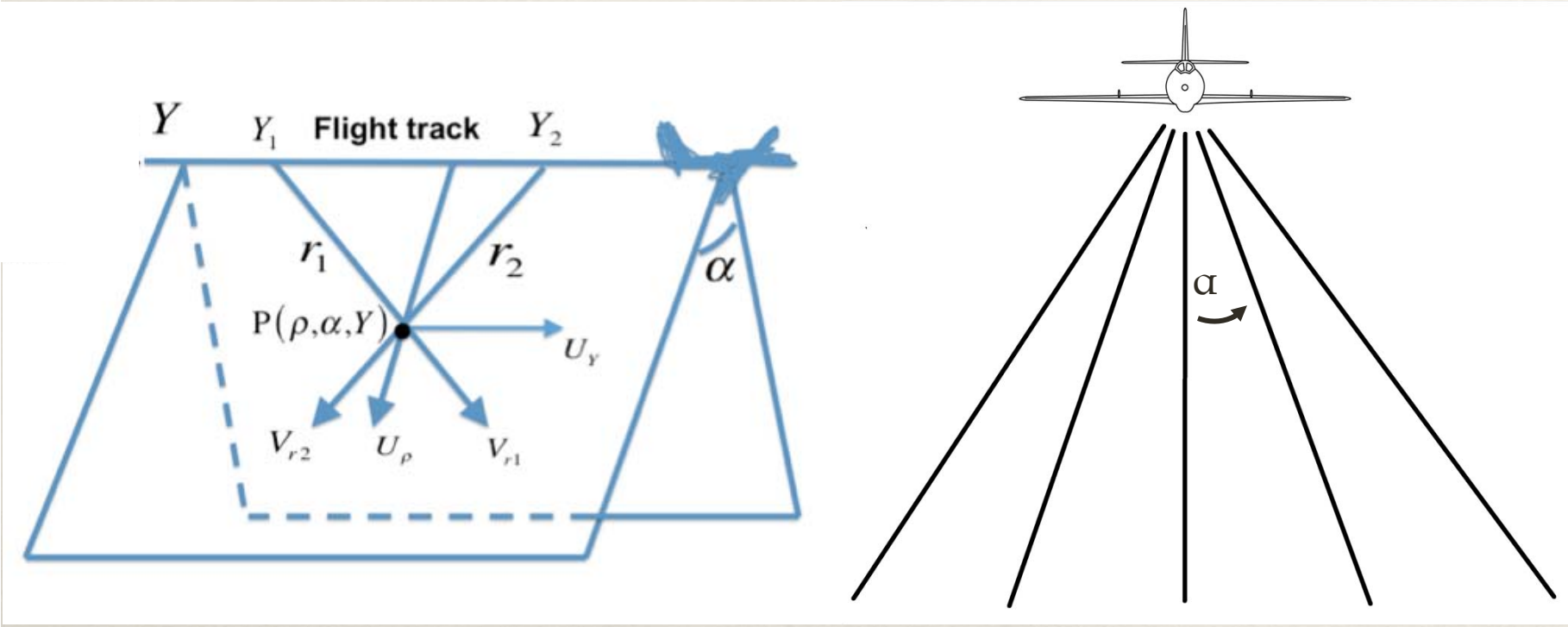
- Gamache 1997, Gao et al. 1999, Reasor et al. 2009
- Finds wind field that best fits observations
- Mass continuity constraint
- Global solver





Coplanar method

- Applied for ground radars; Armijo 1969, Lhermitte and Miller 1970
- Natural coordinates of scanning observations
- Calculates two components in each plane



Coplanar method

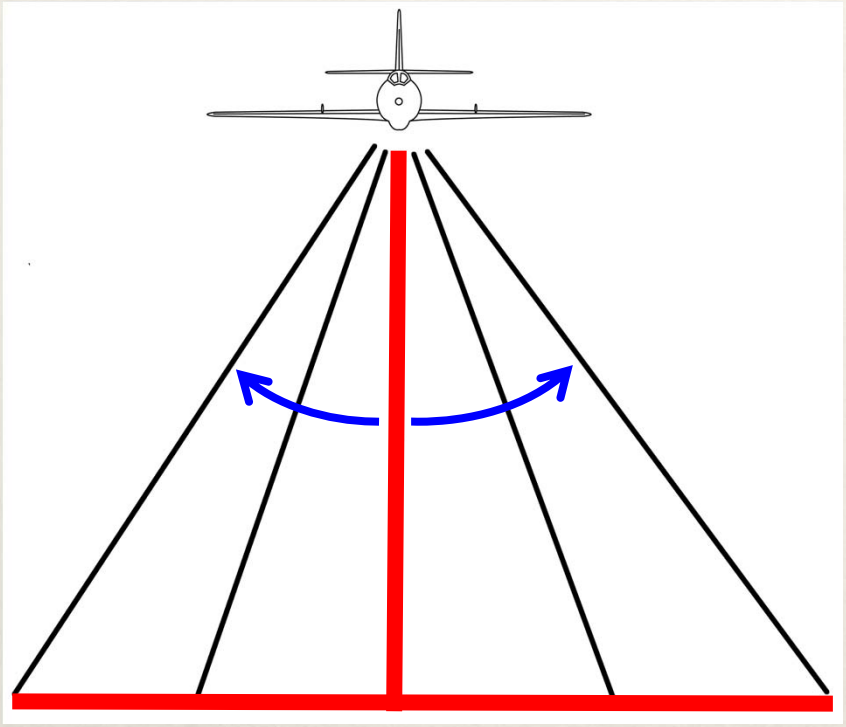
- Third wind component retrieved by integration

Surface boundary condition

- Vertical wind is zero

Nadir boundary condition

- Estimate of cross-track wind
- Uses observations slightly off-nadir
- Assumes constant vertical velocity, linear cross-track velocity across observations



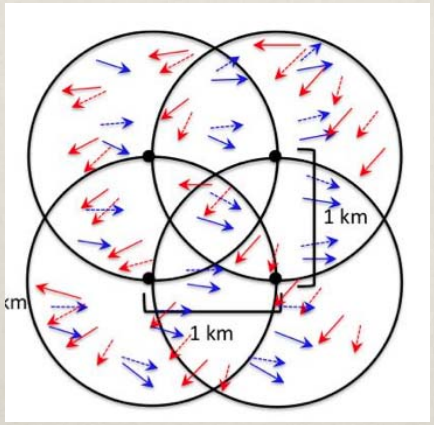
Cost function optimization

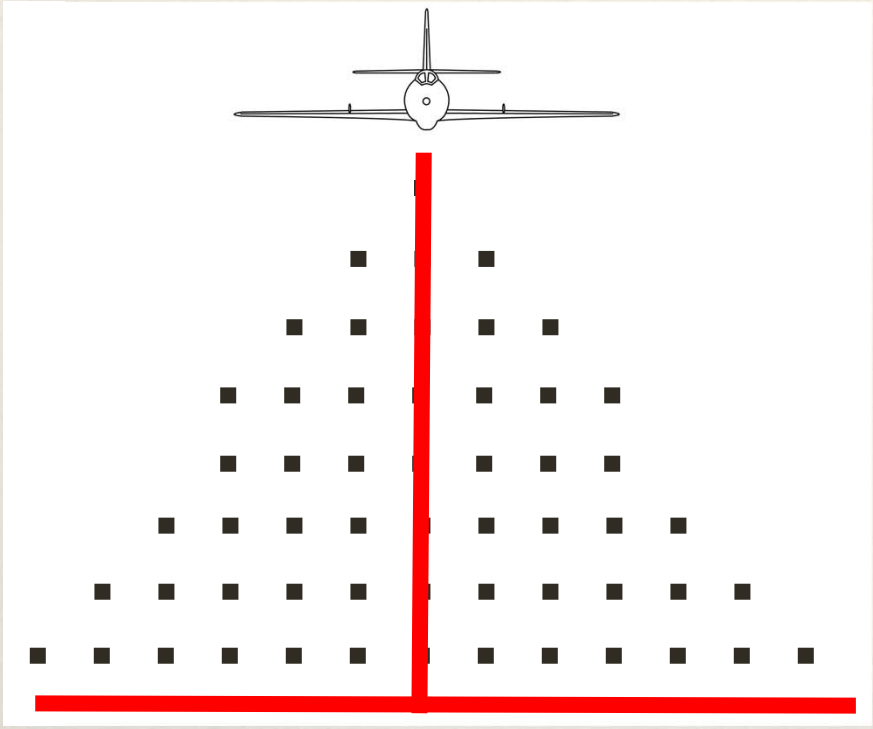
- Minimizes differences between solution and observations
- Boundary conditions at surface and nadir

$$F = \lambda_1 F_1 + \cdots + \lambda_N F_N + \lambda_{N+1} F_{N+1} + \lambda_{N+2} F_{N+2} + \lambda_{N+3} F_{N+3} + \lambda_{N+4} F_{N+4}$$

$$F_n = \sum_{m=1}^{M_n} \sum_{k=1}^{K} \sum_{j=1}^{J} \sum_{i=1}^{I} \delta_{ijkm} [V_{R,mn} - \alpha_{mn} u_{ijk} - \beta_{mn} v_{ijk} - \gamma_{mn} (w_{ijk} - V_{T,ijk})]^2$$

Reasor et al. 2009

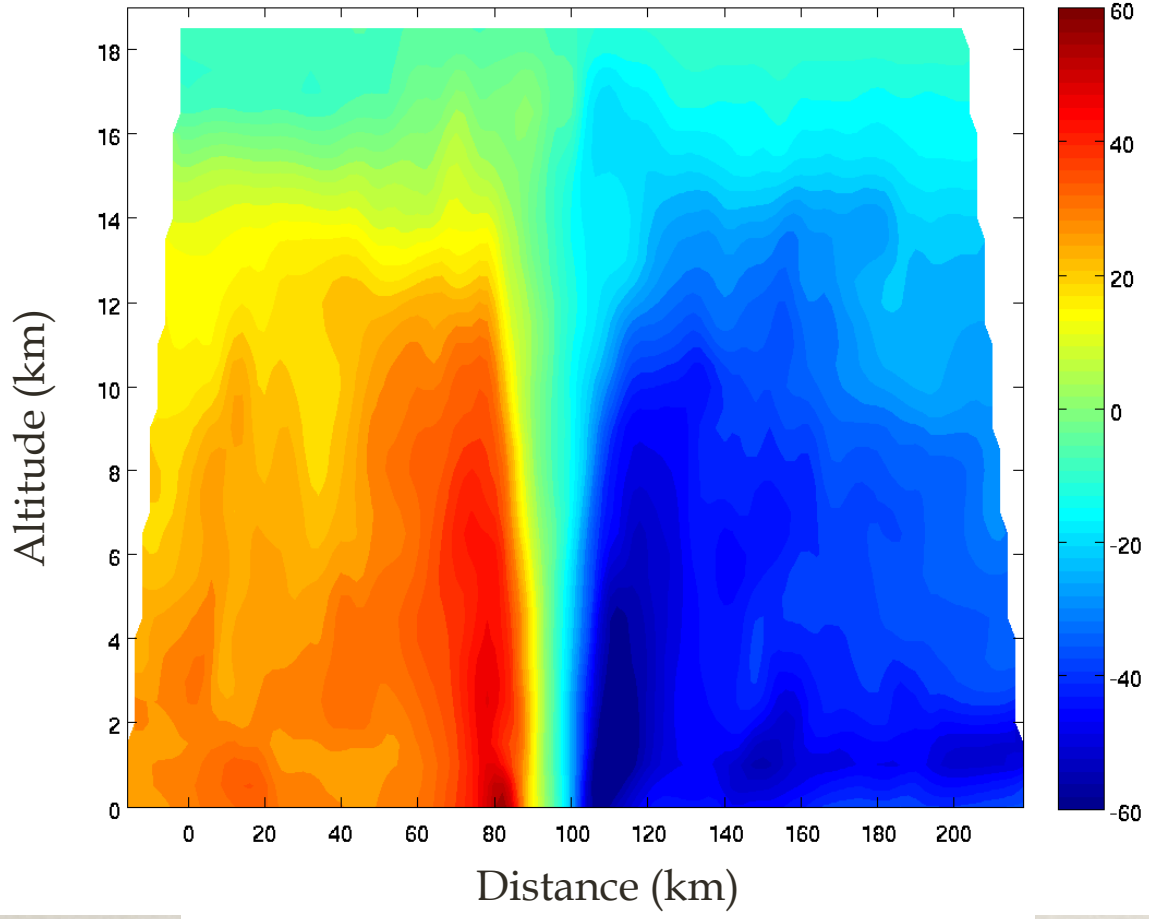




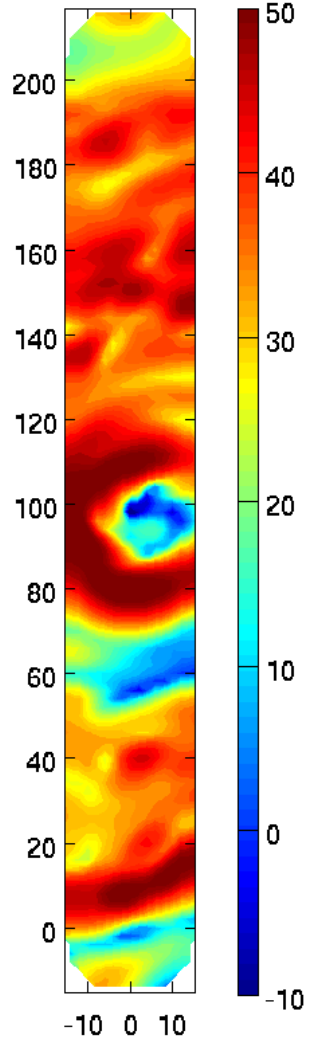
Radar simulator

- Simulated radar scan of model data

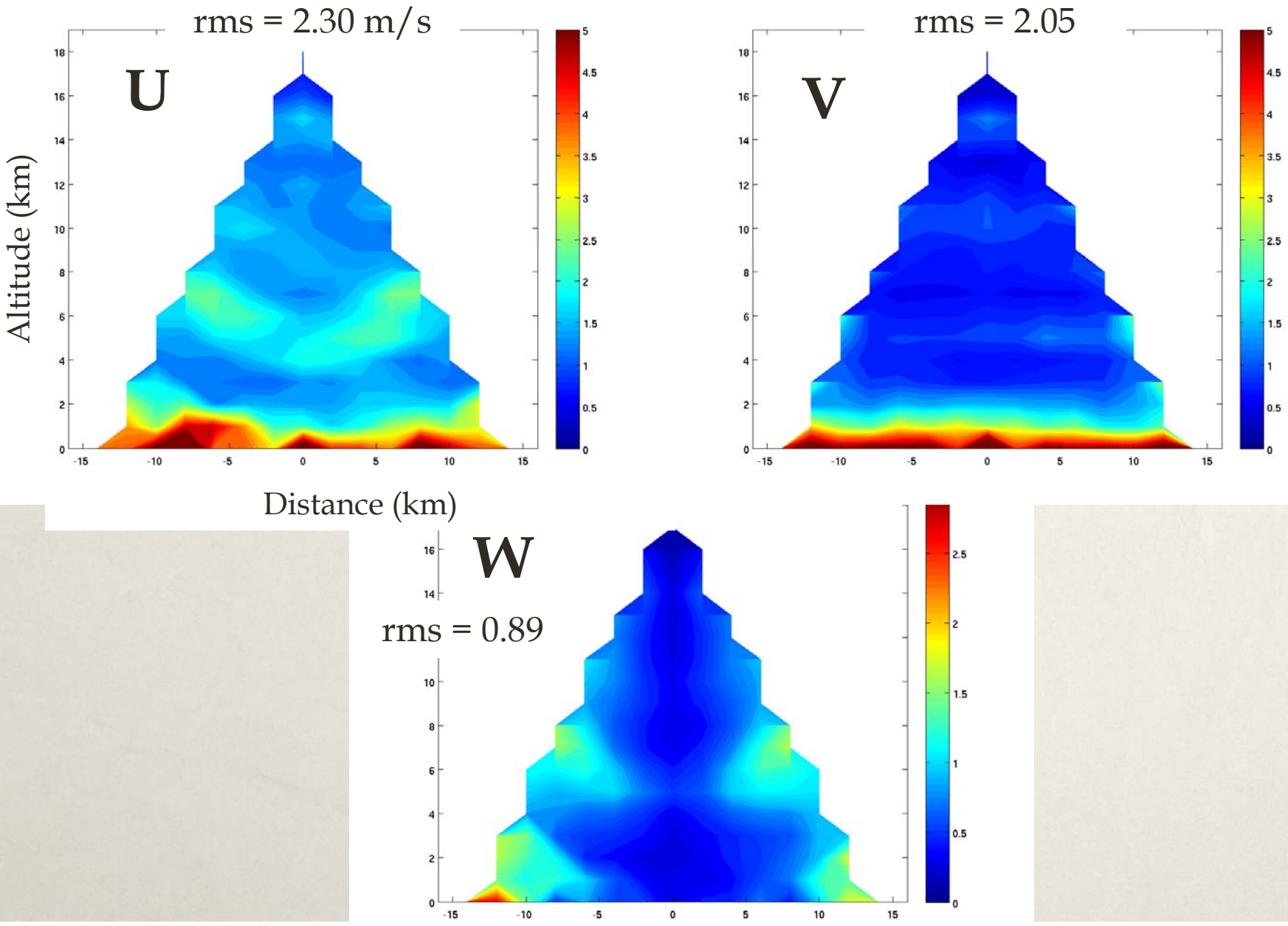
Cross-track velocity (m/s)



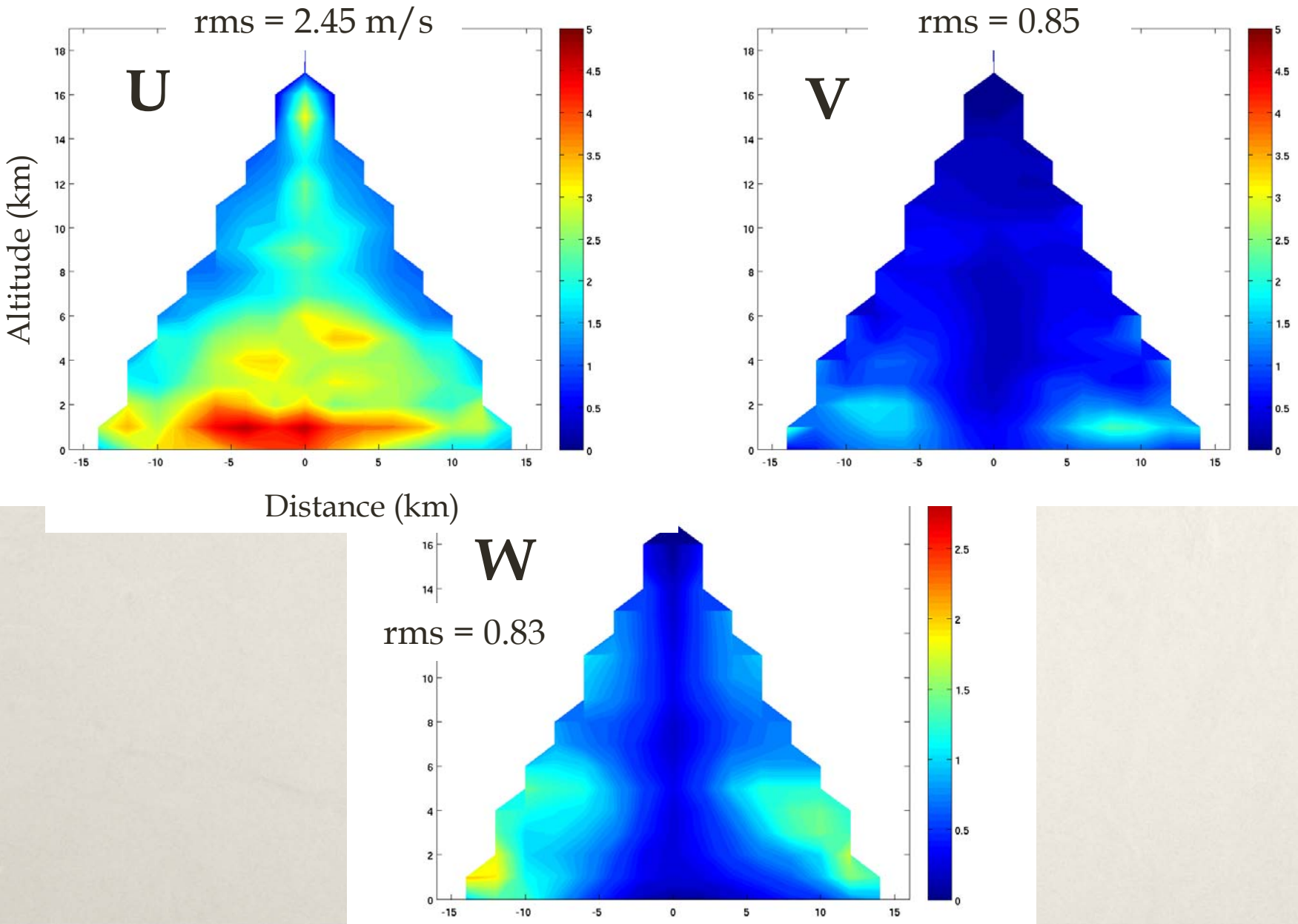
Reflectivity (dBZ)



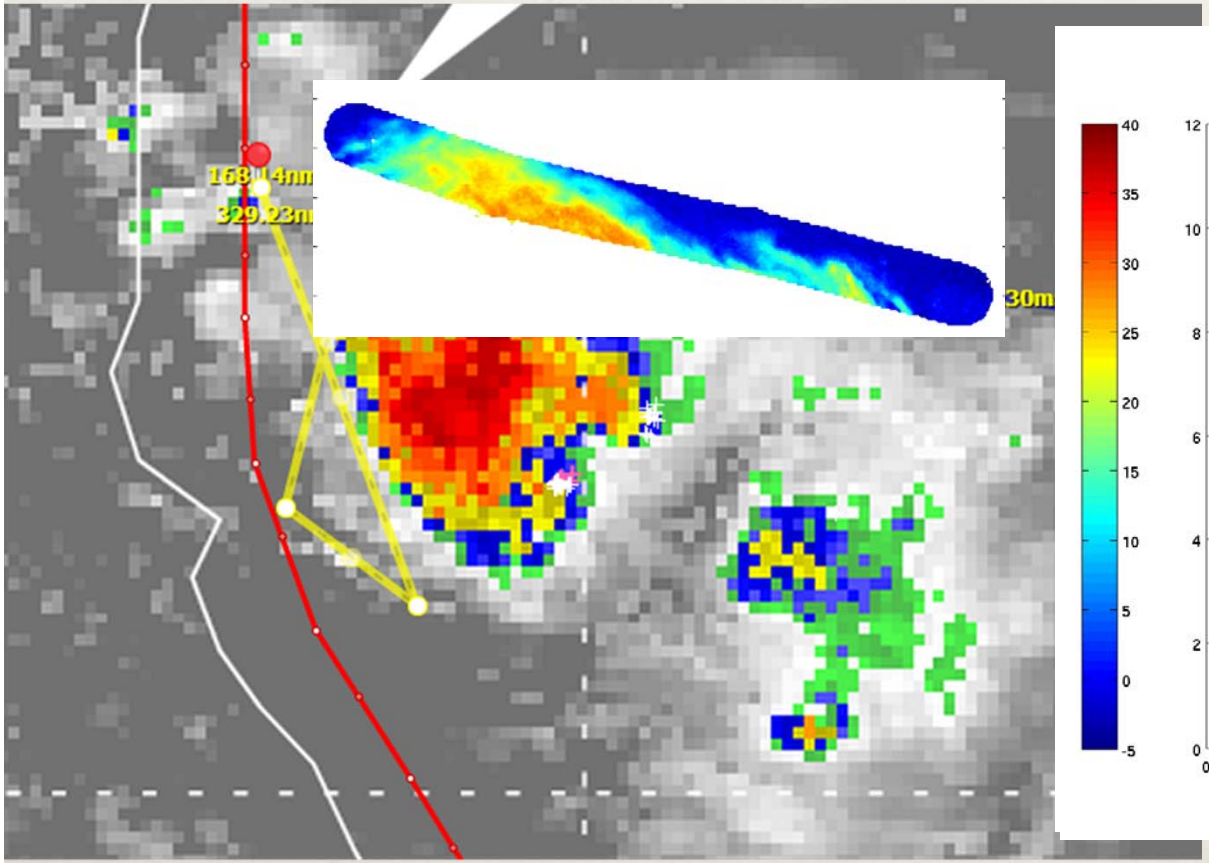
RMS Errors: Coplanar method



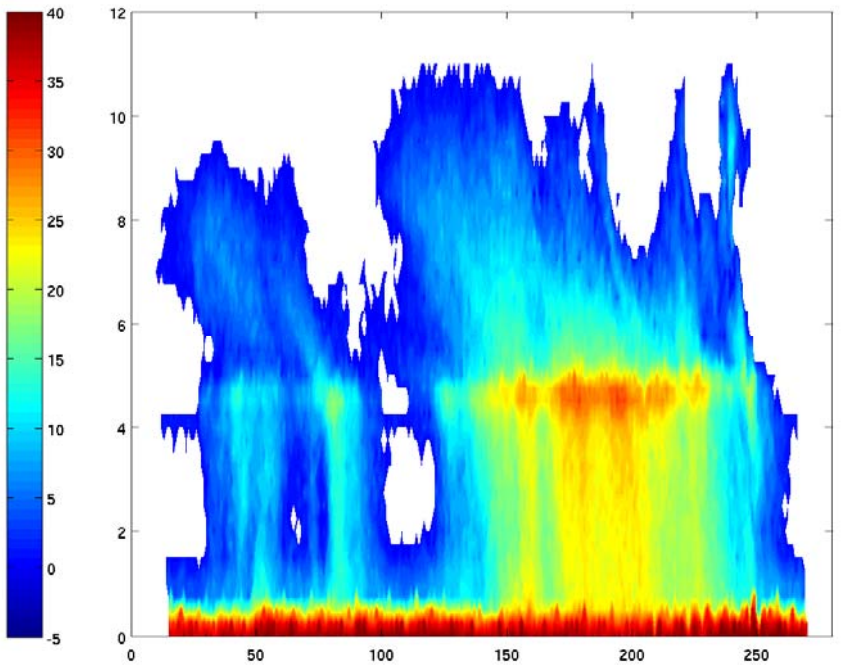
RMS Errors: Optimization method



Hurricane Ingrid (2013)



Nadir cross section: Reflectivity

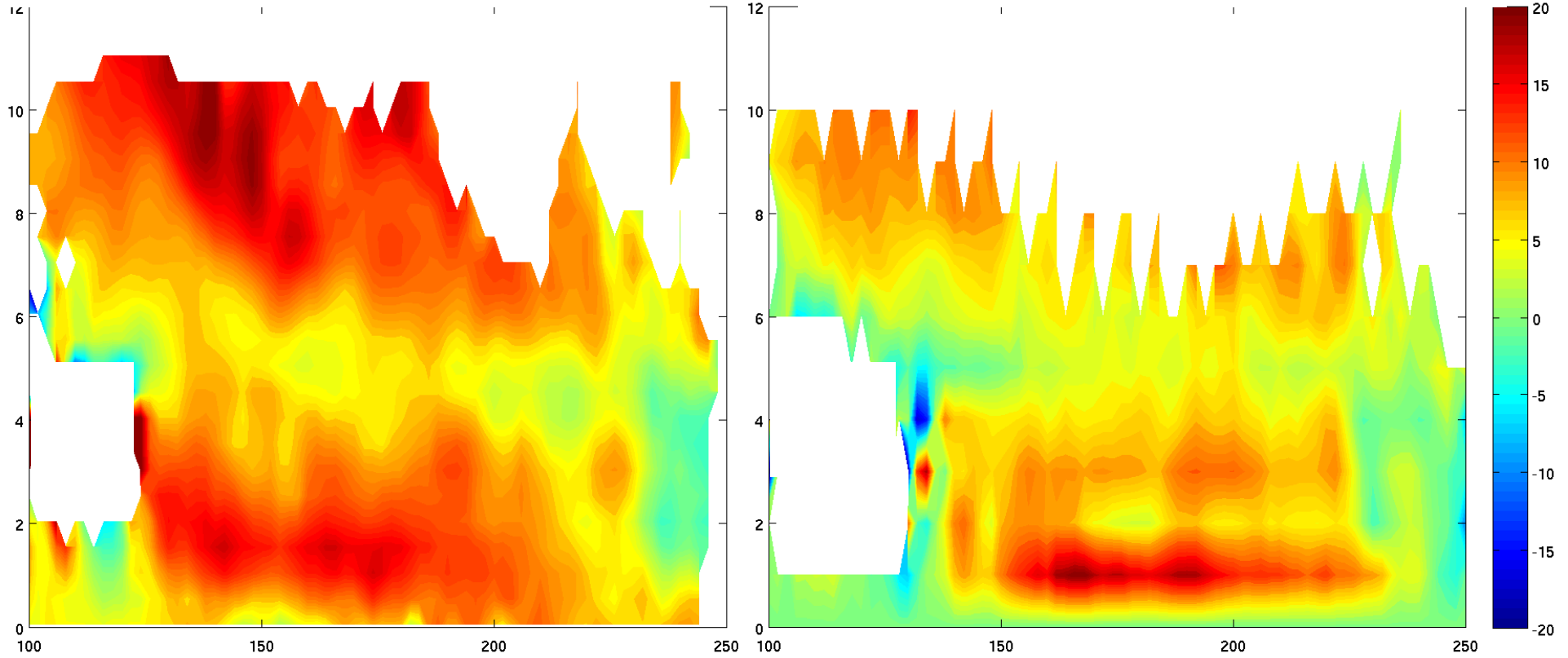


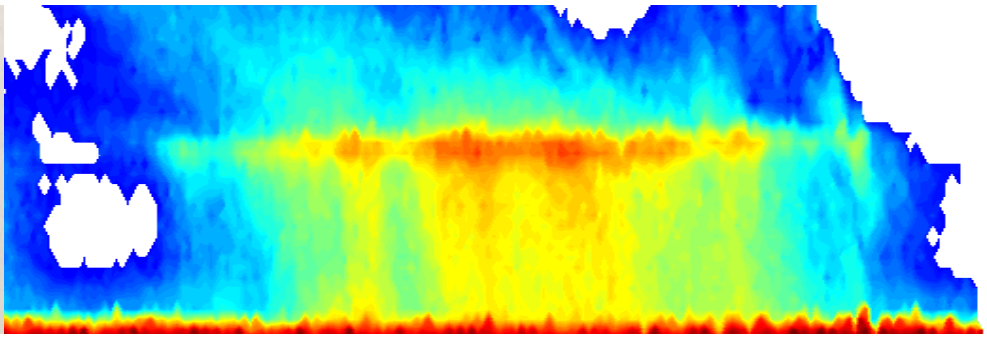
15 Sept 2014 1836-1900Z

Cross-track wind component

Coplanar method

Optimization method





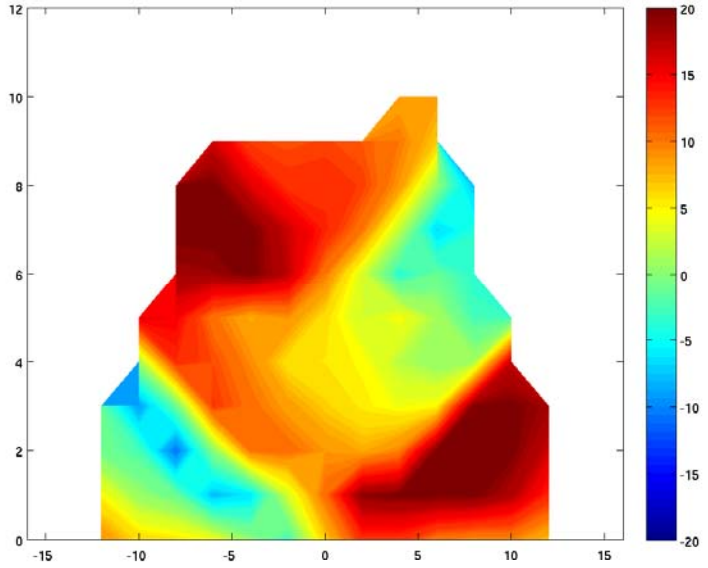
Nadir cross section

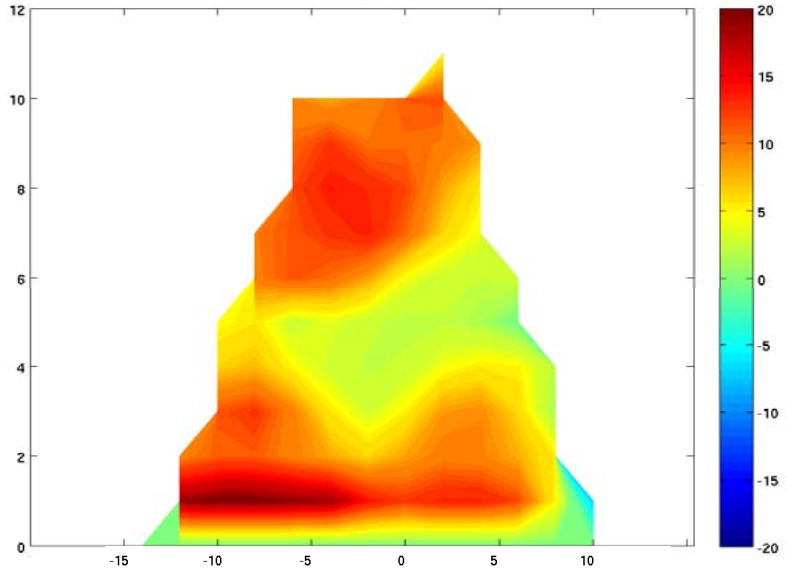
Cross-track wind component

Coplanar method

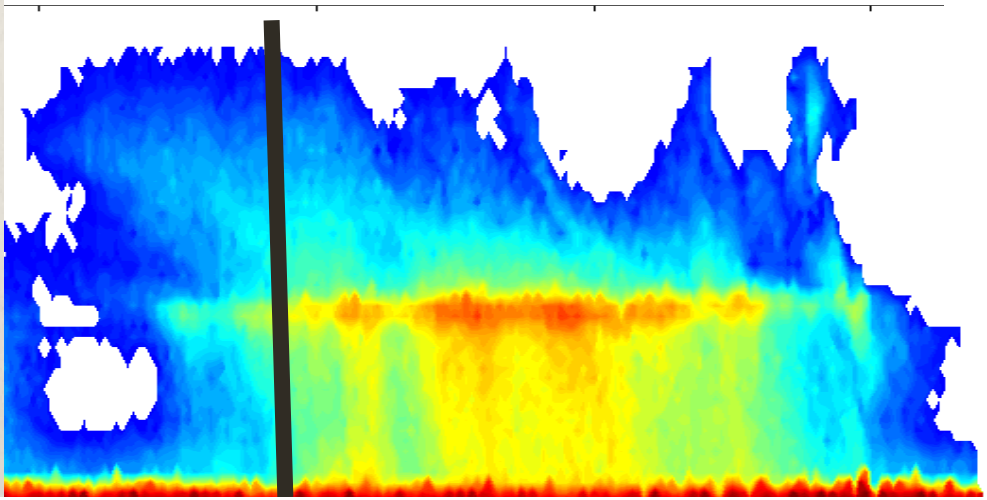
Optimization method

m/s





Distance (km)



Cross-track cross section

Work in progress

- Sensitivity in retrieval parameters
  - Observation swath for nadir estimation
  - Weighting parameters in cost function
  - Filtering effect
- Variational nadir estimation
- Improvements in fall speed correction

Conclusions

- Dual-Doppler retrieval methods used in traditional airborne radars successfully applied to HIWRAP geometry.
- In simulation, Coplanar method retrieved wind field well, particularly cross-track winds.
- Optimization method retrieved along-track velocities and vertical velocities well.
- Wind retrievals of Hurricane Ingrid were mostly in good agreement.

Questions?