



# DESDynI-R: Radar-only version of DESDynI

### **Overview of Current Status**

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### Dynl-R Ecosystems Science Flowdown (conceptual)

Decadal Survey Science Questions	How are the Earth's carbon cycle and ecosystems changing and what are the consequences for ecosystem sustainability and services?		F a c s	How do changes in climate and land use affect the carbon cycle, agricultural systems and biodiversity?					
SAR Mission Science and Applications Objective	Determine the changes in carbon resulting from disturbance and subsequent regrowth of woody vegetation systems	Determine the extension of wetlands and the dynamics of floode areas		it	Determine the area and crop yield of agricultural systems and their changes		Understand the impacts of ecosystem structure and its dynamics on biodiversity and habitat		
Measurement Objective	Measure global woody aboveground biomass below 100 Mg/ha at 20 Mg/ha accuracy, and disturbance/recovery, at hectare scale, annually		Acquire targeted data sets to characterize wetlands, inundation, and agricultural systems			Explore potential of backscatter and interferometry for measuring vertical canopy structure over a sampling of forested biomes on a seasonal basis		catter isuring ver a es on a	
Measurement Requirement	Produce global estimates of aboveground woody biomass within the greater of 20 Mg/ha or 20% at 1 ha resolution globally for areas of low biomass annually ( < 100 Mg/ha).	Map global areas of vegetation disturbance ha resolution annually areas losing at least 50 canopy cover with a classification accuracy 20%		1	Map regional areas of wetlands at 30 m resolution and measure inundation dynamics (timing and area) every 12-24 days at 30 m resolution at 20% accuracy.		tion ea) m acy.	Map regional crop area and biomass (< 25 Mg/ha) at 1 ha resolution every 12-24 days. Crop area accuracy shall be <10% and biomass error < 30%.	



DESDynI-R

April 12, 2013

#### **Biomass Regions**







Regions with AGB < 100 90% of area Regions with AGB > 100 90% of area



Regions with Slopes > 20% 90% of area



Regions with No woody vegetation

Arctic Regions



#### NEW DIRECTIONS AND STUDIES FOR A US SPACEBORNE SAR MISSION

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# **Decadal Survey: DESDynI Science**



- Recommended by the NRC Decadal Survey for near-term launch to address important scientific questions of high societal impact:
  - What drives the changes in ice masses and how does it relate to the climate?
  - How are Earth's carbon cycle and ecosystems changing, and what are the consequences?
  - How do we manage the changing landscape caused by the massive release of energy of earthquakes and volcanoes?
- Planned by NASA as one of the following 4 Decadal Survey TIER 1 Missions

SMAP
ICESat-II
DESDynl
CLARREO



- Will there be catastrophic collapse of the major ice sheets, including Greenland and West Antarctic and, if so, how rapidly will this occur?
- What will be the time patterns of sea level rise as a result?
- Changes in ecosystem structure and biomass
  - How does climate change affect the carbon cycle?
  - How does land use affect the carbon cycle and biodiversity?
  - What are the effects of disturbance on productivity, carbon, and other ecosystem functions and services?
  - What are the management opportunities for minimizing disruption in the carbon cycle?
- Extreme events, including earthquakes and volcanic eruptions
  - Are major fault systems nearing release of stress via strong earthquakes?
  - Can we predict the future eruptions of volcanoes?





Biomass



Deformation

Ice Dynamics

3 - 2



## Science Requires Frequent Revisit, Global Coverage, Reliable Data





January 2011 Mission Concept: L-band Polarimetric Repeat Pass Wide-Swath InSAR







"Get creative ..."

- In June 2011, NASA directed JPL to study Synthetic Aperture Radar mission options that fit within available funding, under several funding scenarios for the Earth Science Division
- Launch dates and mission duration were to be considered flexible, with additional funds available in later years
- "... but focus on affordability"
- The team was directed to explore affordable options, including international collaboration, and associated risks
- Science should be influenced, but not constrained, by the Decadal Survey
- Saving cost may come at expense of payload or mission capability
- Studies were conducted with input and feedback from DESDynI Science Study Group



# **Concepts studied**



- Five general concepts were explored, with variants on each
  - 1. US-only scaled back radar capability to single-pol, half-swath
  - 2. US-only scaled back to fit in smaller launch vehicle
  - 3. International partner co-develops Tandem L-band radar spacecraft
  - 4. International partner provides spacecraft; multi-frequency mission
  - International partner provides spacecraft, and launch vehicle; multifrequency mission
- For all concepts, the fundamental reflector-based SweepSAR architecture was preserved
  - Previous studies suggested significant cost penalties for planar arrays of this size class
  - Strong investment in current instrument risk reduction activities (see next slide)
- Remainder of this talk will focus on concepts 2 & 5 above





### **SweepSAR Airborne Demo Data Processing**

- Invested in demonstration of SweepSAR in an airborne environment using Ka-band multi-channel prototype system
- Hardware and processing demonstrate efficacy of SweepSAR in configurations that are not ambiguity limited
- Future tests will explore transmit blanking gaps and ambiguity performance.



DBF Image from Flight Line 3

Image from Flight Line 7 Hensley/Ghaemi, Nov 16, 2011 7





- All international partnerships recognized the benefits of frequency and/or baseline diversity
- For this presentation, we consider dual-band, shared-reflector case
  - Preserve SweepSAR with reflector (12-m reflector; multi-element feed)
  - Preserve quad-pol or dual-pol
  - Consider L-band and S-band dual-band capability
  - Attempt to design for good performance during simultaneous operation
  - Consider 12-day repeat
- Science
  - Global science mission preserving original L-band radar objectives
  - Targeted science studies where S-band or dual-band is most suitable





- Globally distributed measurements at S-band for science applications would be an interesting new data set
- Combination of simultaneous S-band and L-band data would be extremely powerful for discriminating differential scales in many disciplines
- In combination, extends the accuracy of low biomass (< 100 Mg/ha) estimates, and sensitivity to regrowth
- Interferometric Correlation at S-band intermediate between C-band and L-band
  - Improves estimate of the ionospheric path delay relative to split spectrum methods where correlation is good (i.e. in moderate to low vegetation)
  - Extends range of deformation sensitivity to lower values where correlation is good
- Greater available bandwidth at S-band than L-band could enable focus on some areas at finer resolution





# L-Band + S-Band Feed RF Aperture





#### Swath



Use of SweepSAR will significantly improve swath width



- ~250 km quad-polarization swath
- L- and S-band systems to operate independently
- 12 day repeat
- Nominal 3 year mission lifetime
- Data distribution and processing issues are being worked out



#### **Near Future Events**



- To move forward on a NASA and ISRO partnership, a Technical Assistance Agreement (TAA; part of ITAR) has to be signed
- Requires approval from the Indian Space Commission and ISRO
- April 9: Indian Space Commission has approved the DESDynI-R concept. Actual TAA to be signed next.
- April 30: NASA Terrestrial Ecology Workshop in La Jolla
- May 16 & 17: DESDynI Science Definition Team Meeting (Washington)
- July/August: Anticipated Mission Confirmation Review (MCR)
- September 2013: Possibly begin phase A?
- Launch in 2020?





#### **Accuracy of L-band Biomass**



ACCEPTED in TGRS

# Analyzing the Uncertainty of Biomass Estimates from L-Band Radar Backscatter Over the Harvard and Howland Forests

Razi Ahmed, Member, IEEE, Paul Siqueira, Member, IEEE, and Scott Hensley, Senior Member, IEEE





 Based on difference between ground validation and observations of RCS, it is possible to make prediction intervals for the subplot (25m x 25m) regions and hectare plots.





#### **Simulated Measurement Errors**







