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WETCHIMP-WSL: Intercomparison of wetland methane emissions models over West Siberia

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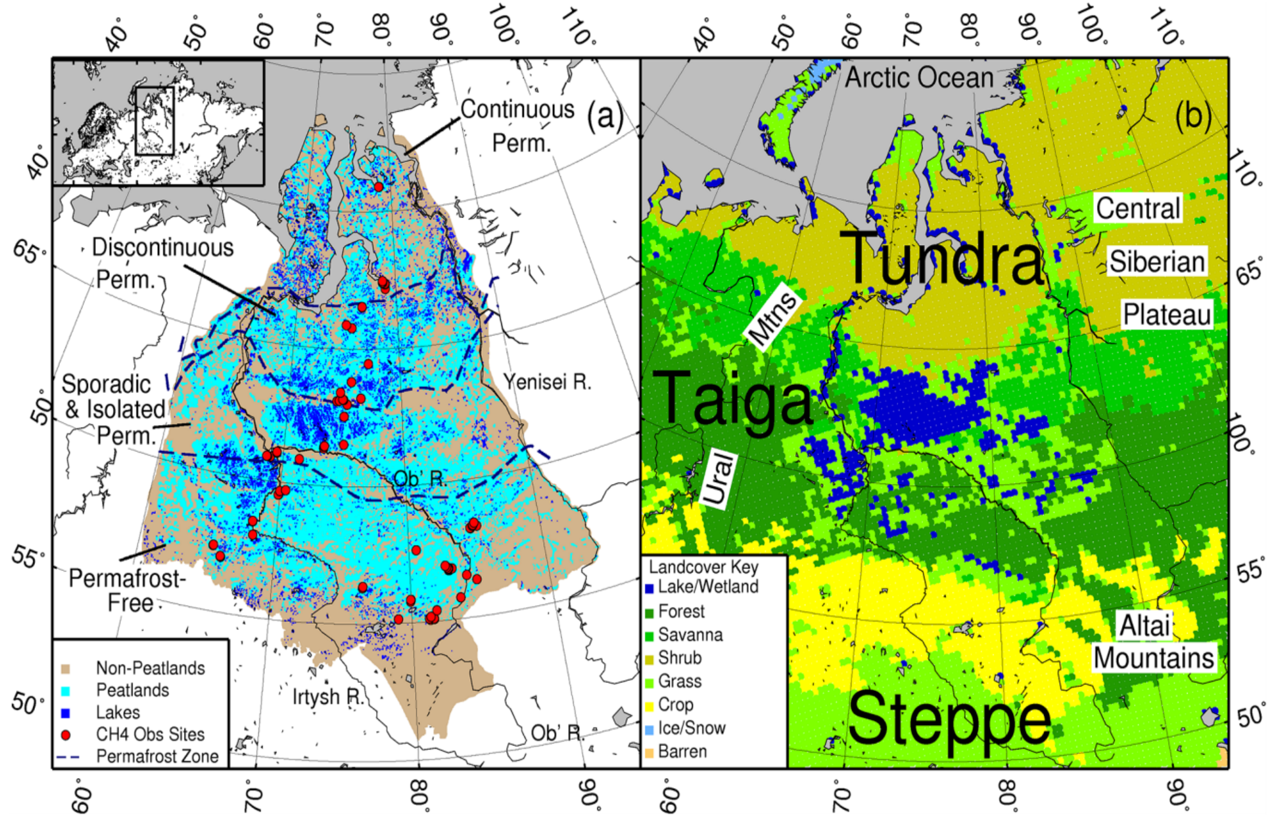
Climate Processes Section
Section des processus climatiques

The Wetland and Wetland CH_4 Intercomparison of Models Project (WETCHIMP)

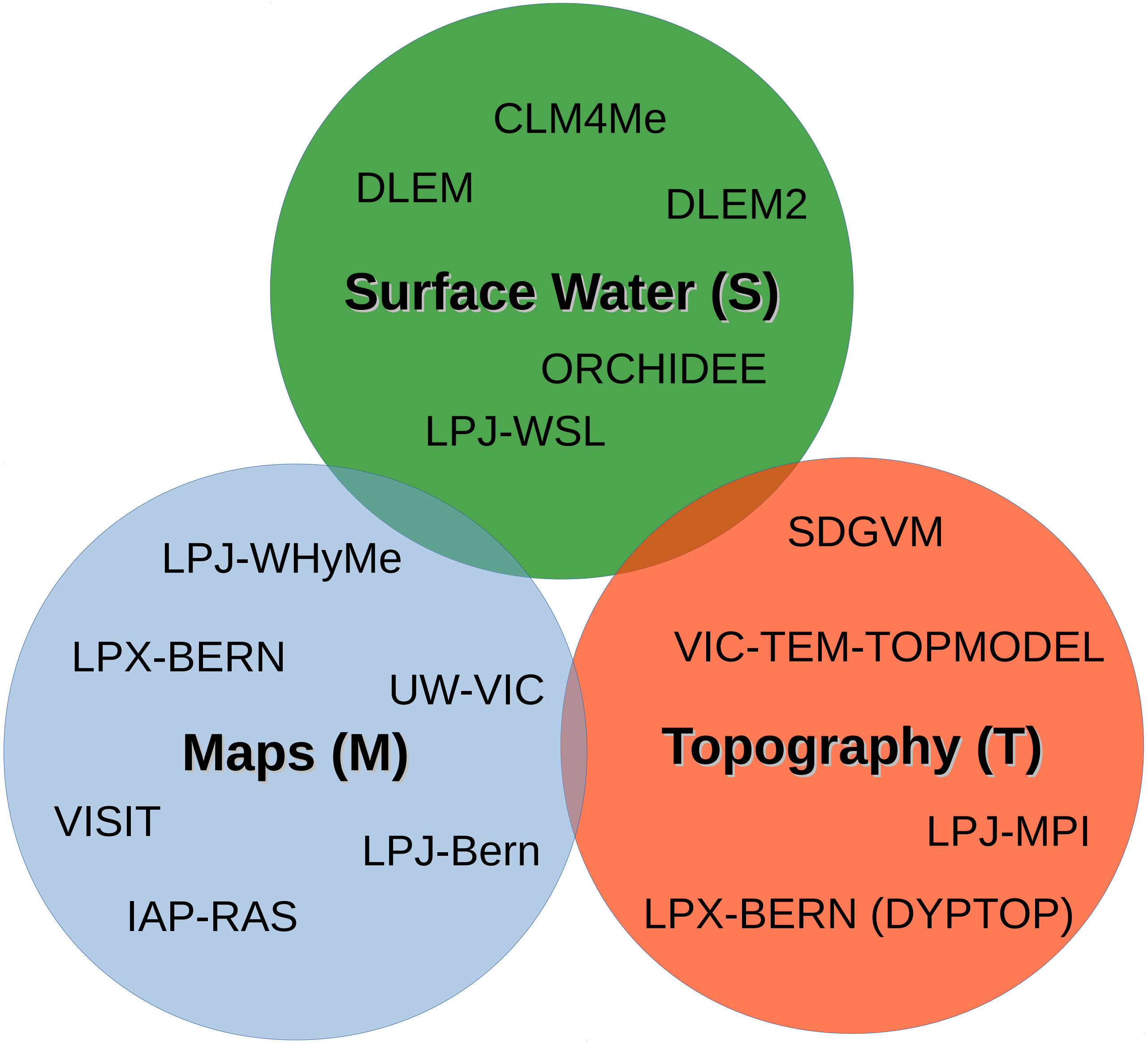
- Intercomparison of global-scale process-based models (Melton et al. 2013 BG, Wania et al. 2013 GMD)
  - Extensive disagreement in simulations of wetland areal extent and CH_4 emissions
    - Annual global CH_4 emissions - models vary ±40 % of all-model mean (190 Tg CH_4 yr^{-1})
  - Observation datasets presently inadequate
  - Substantial parameter and structural uncertainty in large-scale CH_4 emission models
- Regional-scale analysis offers the possibility of improved observations and the opportunity to investigate process parameterizations more closely
  - West Siberian Lowlands (WSL)

West Siberian Lowlands



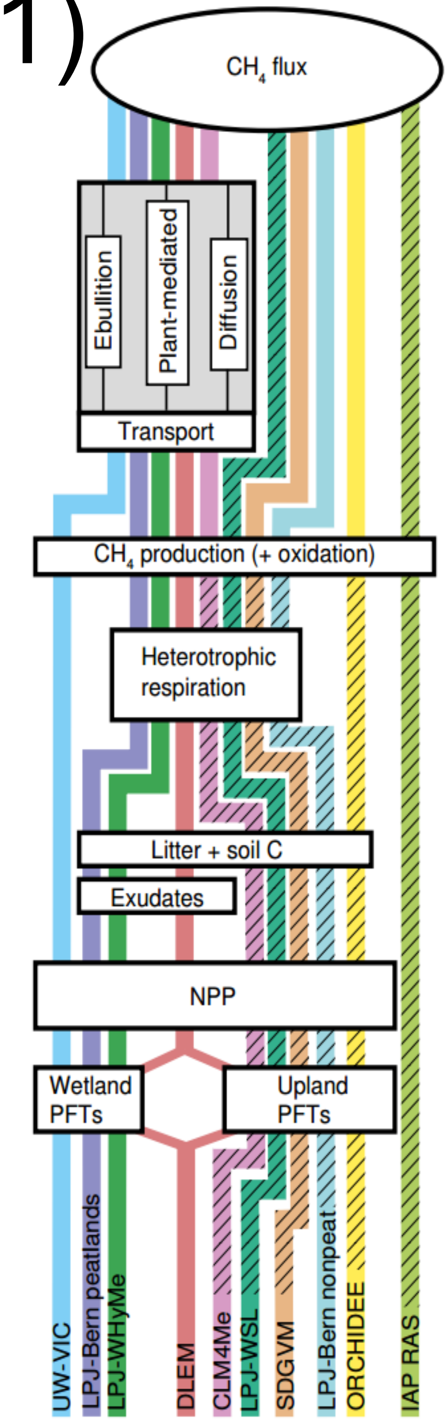
- Good observation dataset coverage
  - CH_4 inventory (1)
    - Glagolev et al. (2011)
  - Wetland maps (4)
    - Sheng et al. (2004), Peregon et al. (2008), NCSCD (Tarnocai et al. 2009), GLWD (Lehner and Döll 2004)
  - Remotely sensed surface water (2)
    - GIEMS (Papa et al. 2010), SWAMPS (Schroeder et al. 2010)
  - Inversions (5)
    - Bloom et al. (2010), Bousquet et al. (2006, 2011), Kim et al. (2011), {Winderlich 2012, Schuldt et al. 2013}

Process-based Models (21)

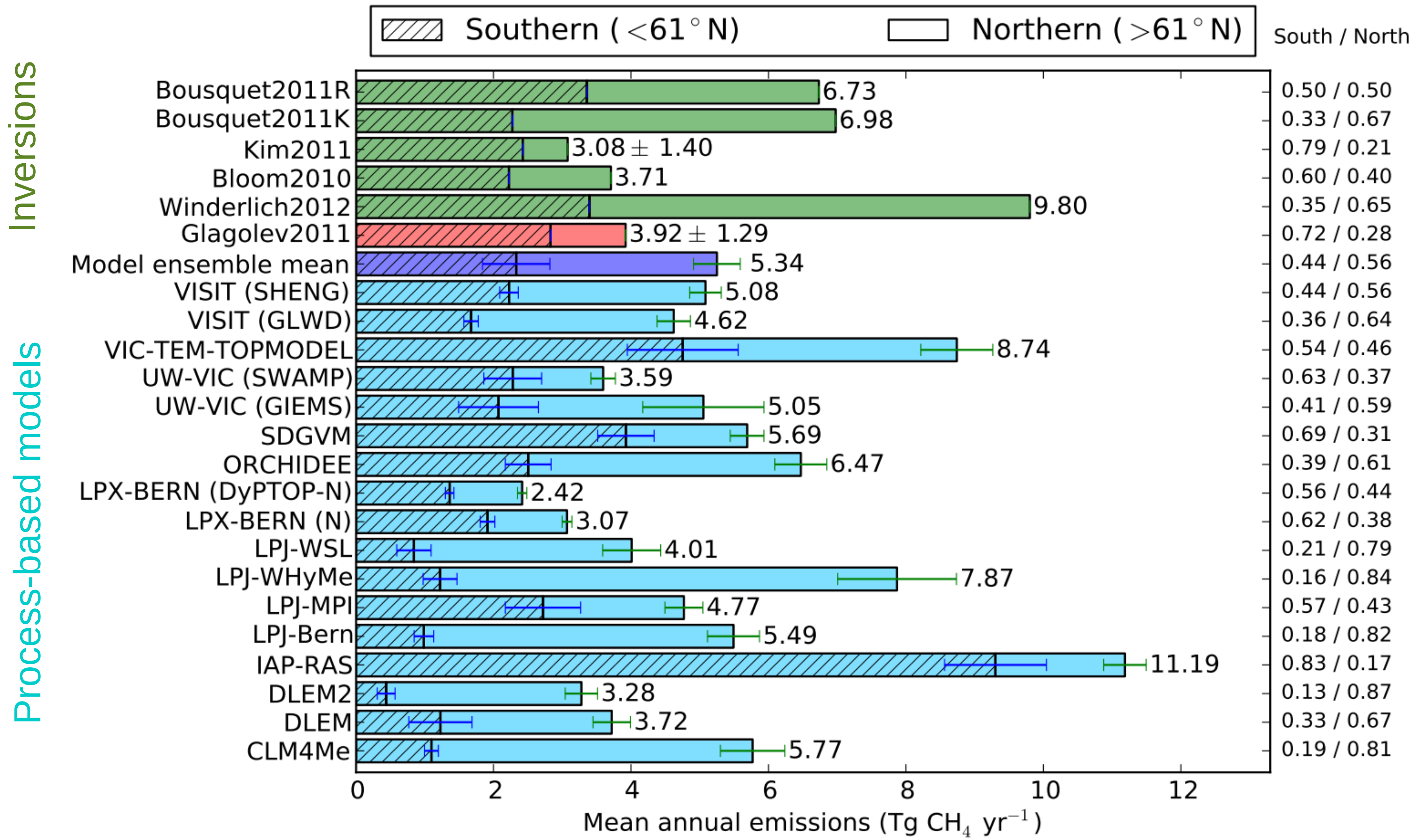


*static wetland maps
with/without S or T
constraints

*with or without
S constraint

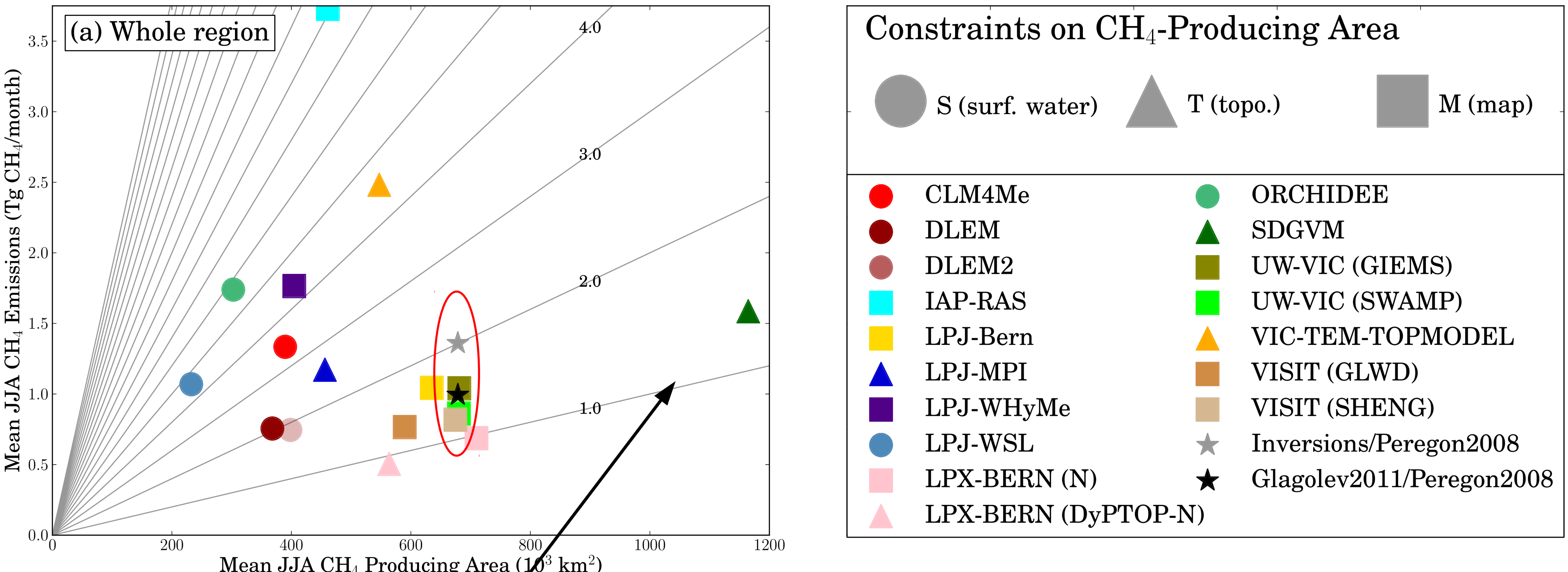


Wania et al. 2013



- Mean annual CH_4 emissions largely agree
  - Forward models: 5.34 ± 0.54 Tg CH_4 y^{-1}
  - Inversions: 6.06 ± 1.22
  - CH_4 inventory (Glagolev2011): 3.91 ± 1.29
- North (Permafrost) / South (Permafrost-free) split differs greatly between models

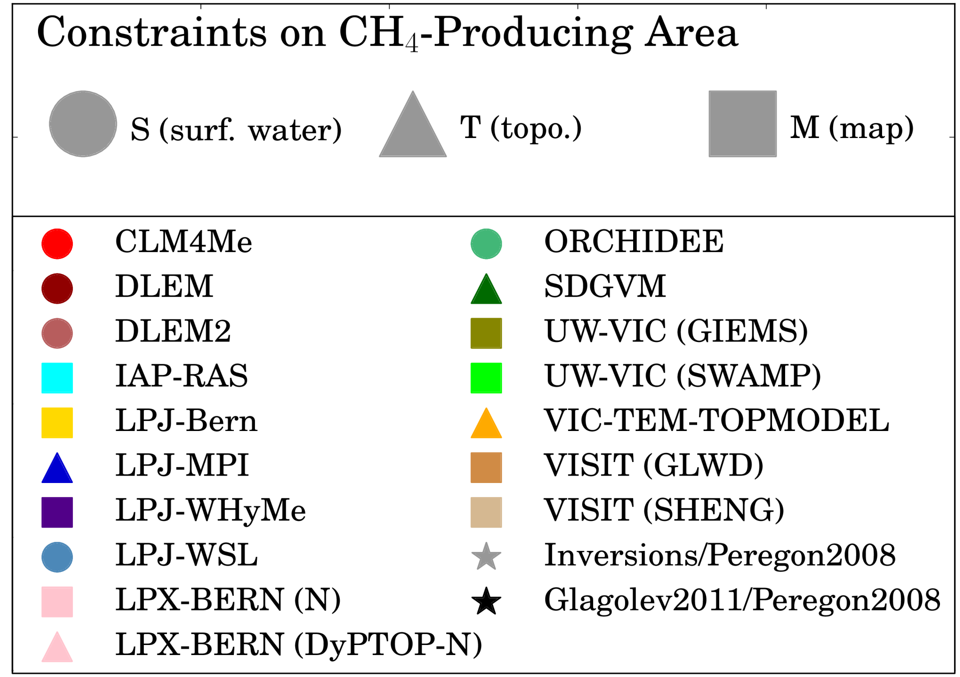
Summer (JJA) CH_4 emissions vs. CH_4 producing area

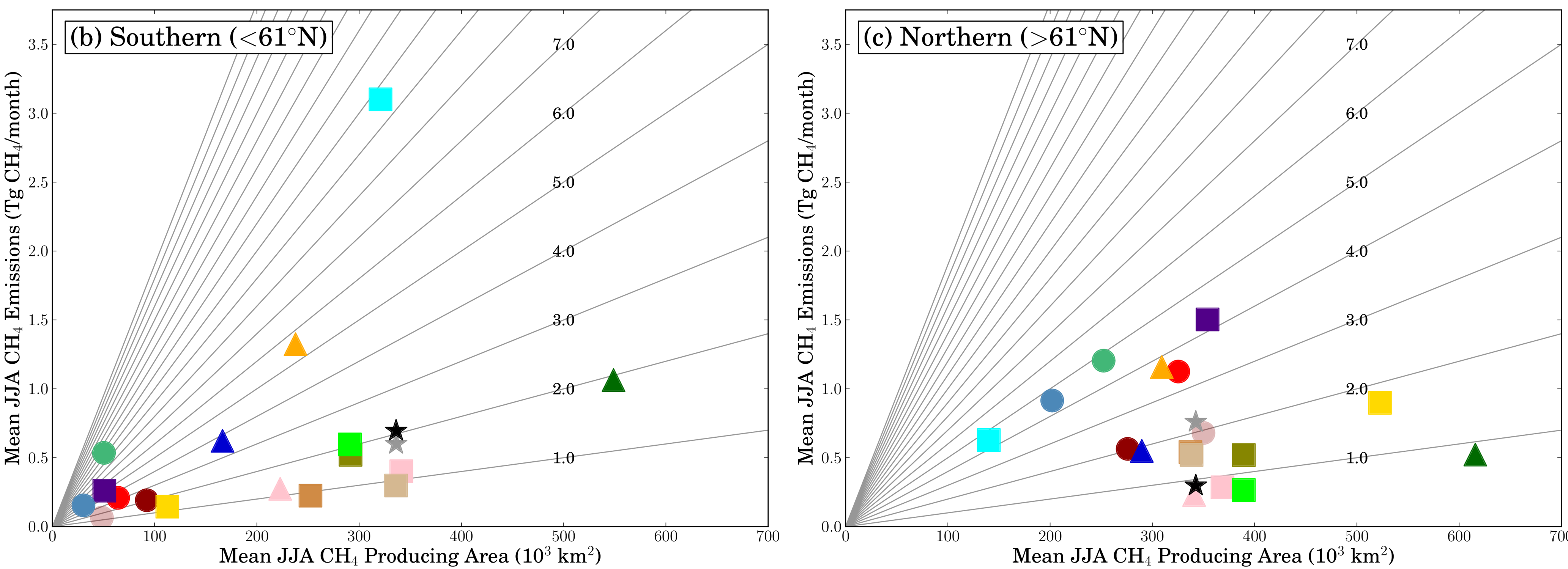


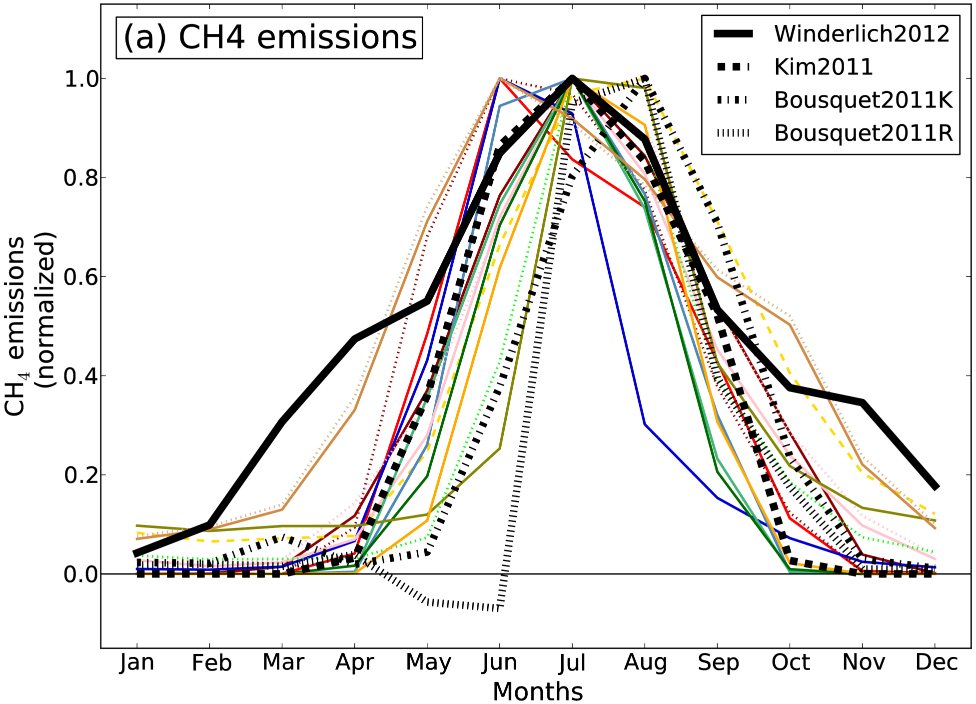
High scatter in wetland area and intensity leads to high scatter in CH_4 emissions

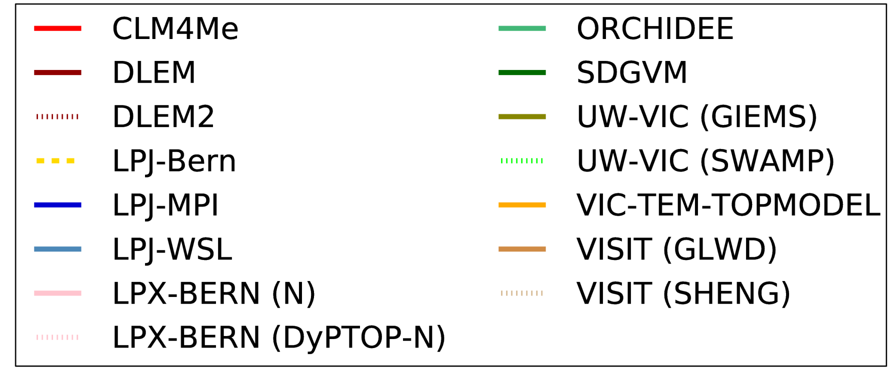
Lines passing through origin are equal intensity
(g CH_4 per month per m^2 wetland area)

- Southern region has strong bias due to small CH_4 producing area
- Primarily S-group models

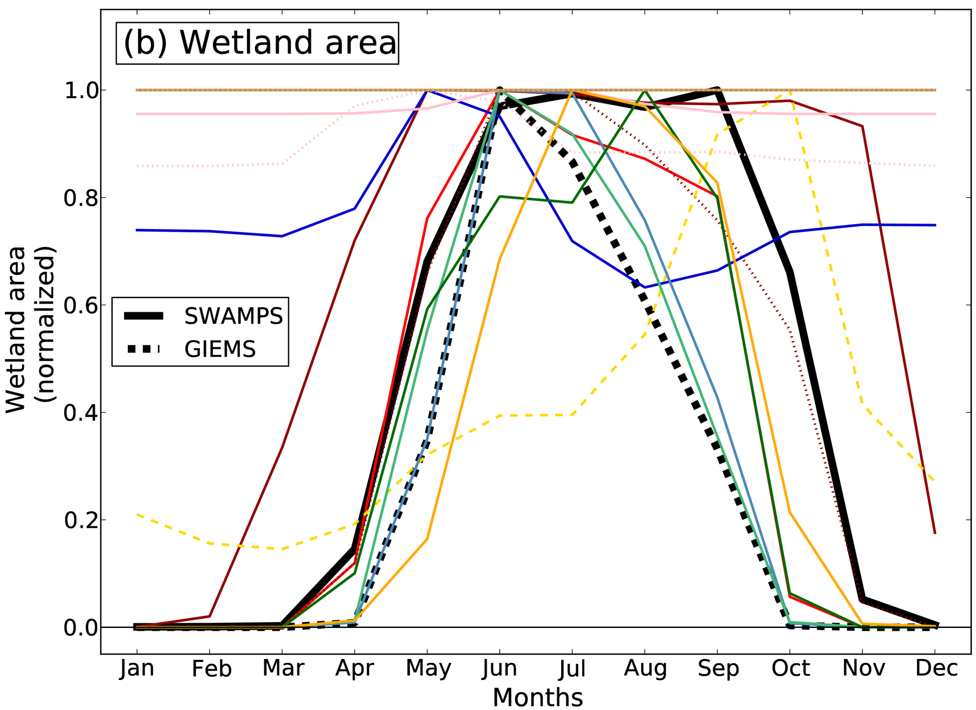


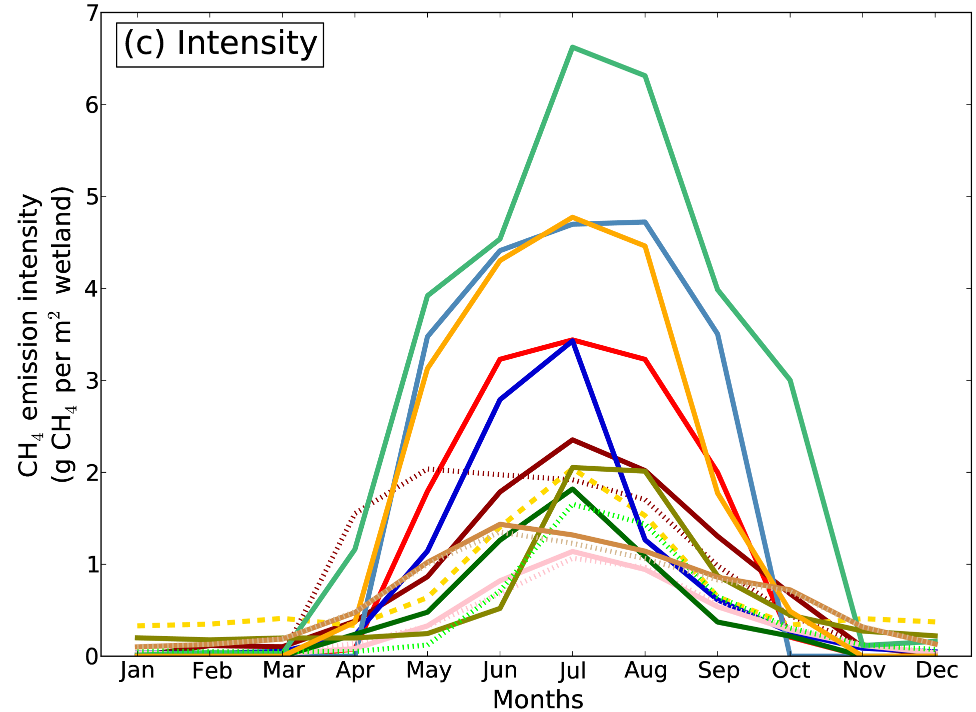


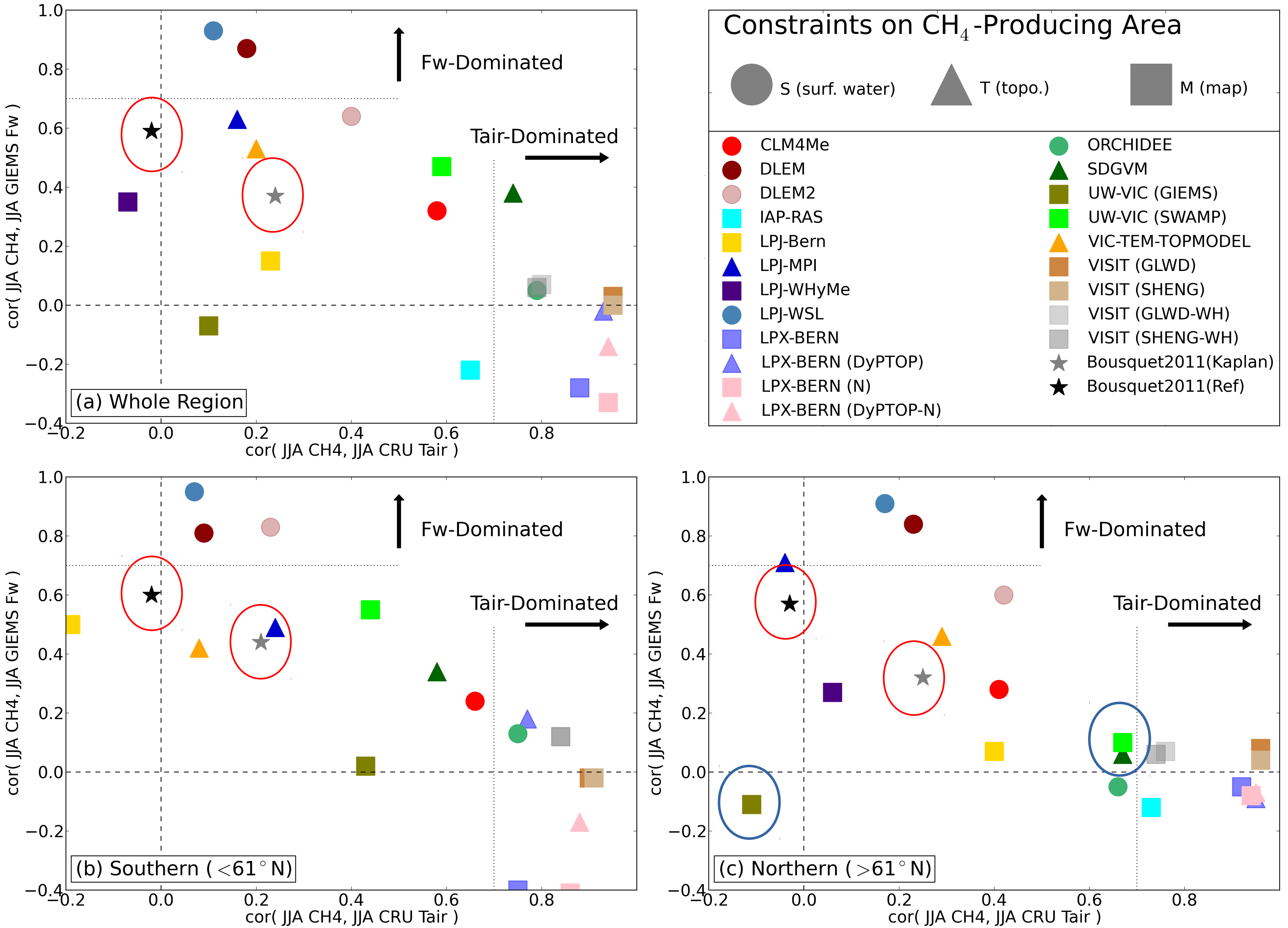




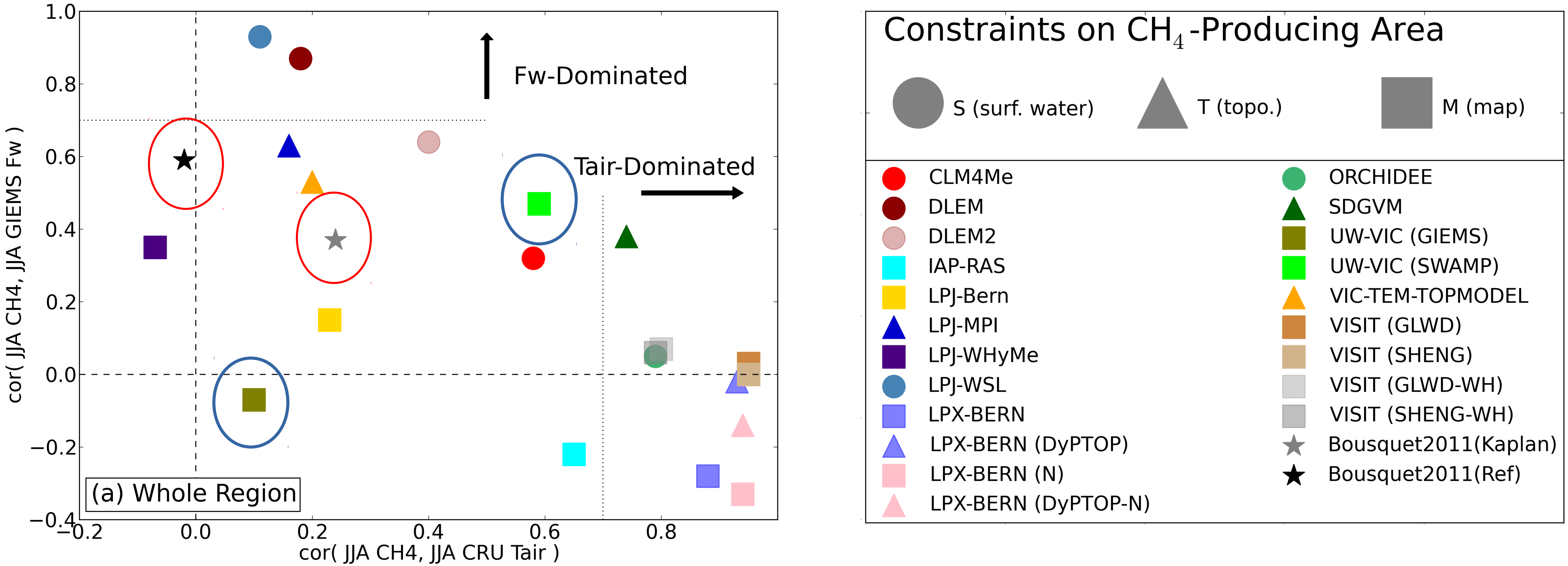
- Good agreement on seasonal cycles of CH_4 emissions but large differences in CH_4 producing area







Constraints on CH4-Producing Area
S (surf. water)
T (topo.)
M (map)
CLM4Me
DLEM
DLEM2
IAP-RAS
LPJ-Bern
LPJ-MPI
LPJ-WHyMe
LPJ-WSL
LPX-BERN
LPX-BERN (DyPTOP)
LPX-BERN (N)
LPX-BERN (DyPTOP-N)
ORCHIDEE
SDGVM
UW-VIC (GIEMS)
UW-VIC (SWAMP)
VIC-TEM-TOPMODEL
VISIT (GLWD)
VISIT (SHENG)
VISIT (GLWD-WH)
VISIT (SHENG-WH)
Bousquet2011(Kaplan)
Bousquet2011(Ref)
Fw-Dominated
Tair-Dominated
(a) Whole Region
(b) Southern (<61° N)
(c) Northern (>61° N)
cor(JJA CH4, JJA GIEMS Fw)
cor(JJA CH4, JJA CRU Tair)



- Either F_w-dominated or T_{air}-dominated models generally lack realistic soil physics, including freeze-thaw dynamics
- Representation of peat soils also missing in many of the F_w-dominated or T_{air}-dominated
- UW-VIC (GIEMS) vs. UW-VIC (SWAMP) demonstrates importance of surface water dynamics overshadows biogeochemical parameter selection

Impact of biogeochemical parameterizations small compared to soil physics or hydrology

Model	$R_{anaerobic}/R_{aerobic}$	C Substrate Source[a]	pH	Redox State	Dynamic Vegetation	Nitrogen–Carbon Cycle Interaction	Saturated NPP Inhibition	Parameter Selection
CLM4Me	Variable	Cpool	Yes	Yes	Yes	Yes	No	Optimized to various sites
DLEM	Variable	NPP and Cpool	Yes	Yes	No	No	No	Optimized to various sites
DLEM2	Variable	NPP and Cpool	Yes	Yes	No	No	No	Optimized to various sites
IAP-RAS	n/a	Cpool	No	No	No	No	No	Literature; Scaled to global total
LPJ-Bern	Constant	NPP and Cpool	No	No	Yes	No	Yes	Optimized to various sites; Scaled to global total
LPJ-MPI	Constant	Cpool	No	No	Yes	No	Yes	Literature
LPJ-WHyMe	Constant	NPP and Cpool	No	No	Yes	No	Yes	Literature; Scaled to global total
LPJ-WSL	Constant	Cpool	No	No	Yes	No	No	Literature
LPX-BERN	Constant	NPP and Cpool	No	No	Yes	No	Yes	Optimized to various sites; Scaled to global total
LPX-BERN (DYPTOP)	Constant	NPP and Cpool	No	No	Yes	No	Yes	Optimized to various sites; Scaled to global total
LPX-BERN (N)	Constant	NPP and Cpool	No	No	Yes	Yes	Yes	Optimized to various sites; Scaled to global total
LPX-BERN (DYPTOP-N)	Constant	NPP and Cpool	No	No	Yes	Yes	Yes	Optimized to various sites; Scaled to global total
ORCHIDEE	Variable	Cpool	No	No	Yes	No	No	Literature and Optimized to various sites
SDGVM	Variable	Cpool	No	No	Yes	No	No	Literature
UW-VIC(GIEMS)	Variable	NPP	No	No	No	No	Yes	Optimized to sites in Glagolev2011
UW-VIC(SWAMPS)	Variable	NPP	No	No	No	No	Yes	Optimized to sites in Glagolev2011
VIC-TEM-TOPMODEL	Variable	NPP	Yes	Yes	No	No	No	Optimized to various sites
VISIT(GLWD)	Variable	Cpool	No	No	No	Yes (only affects upland CH_4 oxidation)	No	Literature
VISIT(GLWD-WH)	Variable	NPP	No	No	No	Yes (only affects upland CH_4 oxidation)	No	Literature
VISIT(Sheng)	Variable	Cpool	No	No	No	Yes (only affects upland CH_4 oxidation)	No	Literature
VISIT(Sheng-WH)	Variable	NPP	No	No	No	Yes (only affects upland CH_4 oxidation)	No	Literature

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Conclusions

BGD

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- Mean annual CH_4 emissions from CH_4 inventory, forward and inverse models largely agree
- Driving model only with remotely sensed surface water results in severe biases in CH_4 emissions
  - S. Miller's inversion over N. America
- Models lacking realistic soil physics or emissions from unsaturated peatlands tend to be dominated by environmental drivers (F_w or T_{air})
- Differences in biogeochemical schemes show small impact