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The Assimilation of Satellite Derived Sea Surface Temperatures into a Diurnal Cycle Model

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*For y ni ersity of Re ding no t Dep rt ent of E rth ciences i on Fr ser ni ersity B rn y British Co i A C n d
s -pi en

s scepti e to di rn r ing sign s , herefore the ti ing of the o ser tions nd the conditions in hic

tion co p risons re di c t nd errors ry for di erent regions nd ti e sc es ,
in di rn cyc e ode ing the high es re not of concern s no di rn sign for s t high ind speeds ho e er the di rn r ing is ery sensiti e to s ight ch nges in ind speeds t the o es . he ind speed w is i port nt ec se ind stress incre ses ro gh y s w nd i ed yer deepening ith w , herefore e en s ight i ses in N P se s rf ce inds speeds c n e d to syste tic errors in oce n circ tion ode s th t re forced y these inds ind speeds of ess th n s^{-} cco nt for ne r y of g o ho r y er ged inds , e inds re concentr ted in the tropics nd

C re is t en to con ert the si ho r y integr ted so r fro ECM F to ner ti e reso tion th t is critic for reprod cing the di rn cyc e his is chie ed y integr ting the Reed for o er si ho r indo gi ing

$$\int_{T}^{T,} I \, dt \quad \int_{T}^{T,} I_{\downarrow} \quad - \; . \quad n \; . \quad \beta \quad - \alpha \, dt,$$

here I is the tot s rf ce so r r di tion nd $I_{\downarrow}$ is the s rf ce inso tion nder c e r s ies the fr ction c o d co er e is denoted y n edo y α β is the so r noon ng e nd T re the si ho r y eteoro ogic n ysis ti es he eft h nd side of Eq tion is set eq to the integr ted ECM F e nd Eq tion c n then e re rr nged to nd n e ecti e e n c o d p r eter o er this indo

$$n \quad \frac{ \; . \quad \beta \int_{T}^{T,} I_{\downarrow} \quad - \alpha \, dt - \int_{T}^{T,} I \, dt}{. \quad \int_{T}^{T,} I_{\downarrow} \quad - \alpha \, dt}.$$

f it is night so th t $\int_{T}^{T,} I_{\downarrow} \quad - \alpha \, dt$ then persistence n n – denotes e ch hr n ysis ti e is ss ed A chec is so de to enforce the physic c o d i its $\leq n \leq$ he net s rf ce R I sed in the ode r n is c c ted t e ery ti e step sing the Reed for ith the si ho r y deri ed c o d es h s ch ner ti esc e is chie ed hi e the si ho r y integr ted ECM F es re ret ined

ho r y

his section descri es ethod for t ning the c o d co er nd the s rf ce ind speed p r eters s they ppe r in the forcing gorith s for the GO M ode It is ss ed th t these t o p r eters re i e y to e the ost poor y no n fro N P or re n ysis ode o tp t he p r eters re sed to he p GO M t i e s te ite e s re ents inc ding the di rn cyc e co ponent

3.1 The Algorithm

If e rst consider the ode ed θ s f nction of the fr ction c o d co er n nd ind speed forcing w $\sqrt{u \quad v}$

$$\theta \quad \theta \; n, w .$$

P r eters ϵ_A nd ϵ_B re introd ced here

$$n \quad n \quad \epsilon_A,$$

$$w \quad \quad \epsilon_B \; w \; ,$$

$$\quad \epsilon_B \sqrt{u \quad v} \; .$$

hese d st ent p r eters i e ss ed to re in ed o er e ch ho r ti e indo J tho gh the c gro nd d t u v nd n fro ECM F ch nge e ery si ho rs he c o d correction is seen to e n so te error here s the ind correction is fr ction error his oids corrections to ind direction nd o s the strict i its on c o d co er $\leq n \leq$ to e s tis ed he c n no e ie ed s f nction of the p r eters

$$\theta \quad \theta \; \epsilon_A, \epsilon_B \; .$$

e no de ne cost f nction J J ϵ_A, ϵ_B s

$$J \quad \sum \left(H \; \theta^{\text{model}} - \theta^{\text{o s}} \right) ,$$

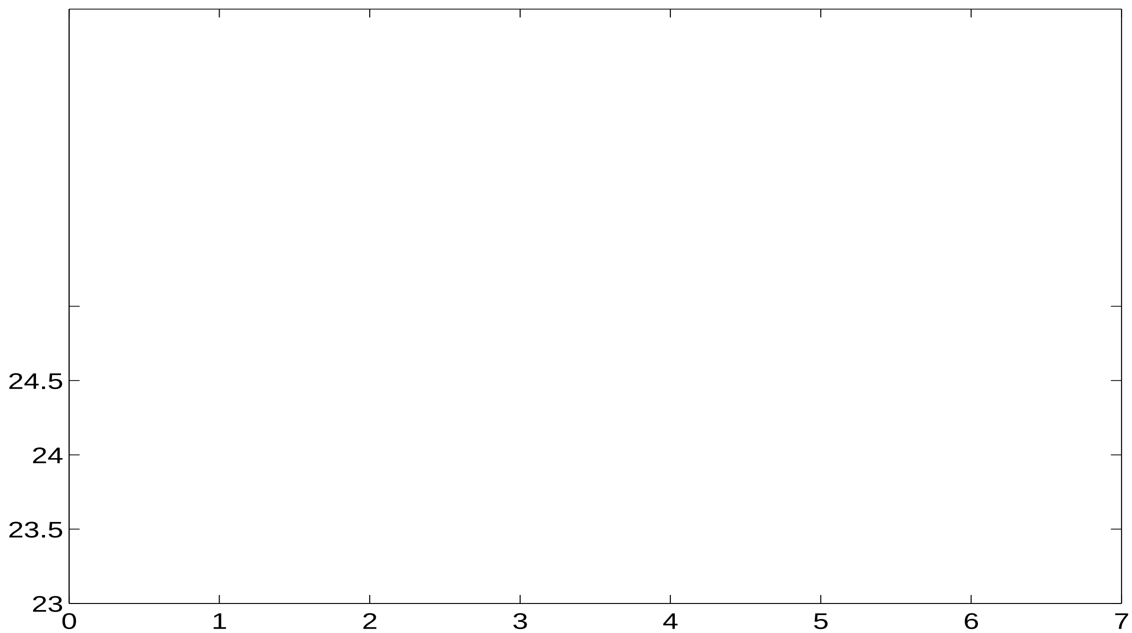
here N is the n er of o ser tions o er the ho r indo nd t $Td \; t$ Td T

$\epsilon_B >$ he d t ssi i tion pro e c n no e st ted s fo o s

An `optimal' parameter pair $\epsilon_A^*, \epsilon_B^*$ **is sought such that for all feasible** ϵ_A, ϵ_B

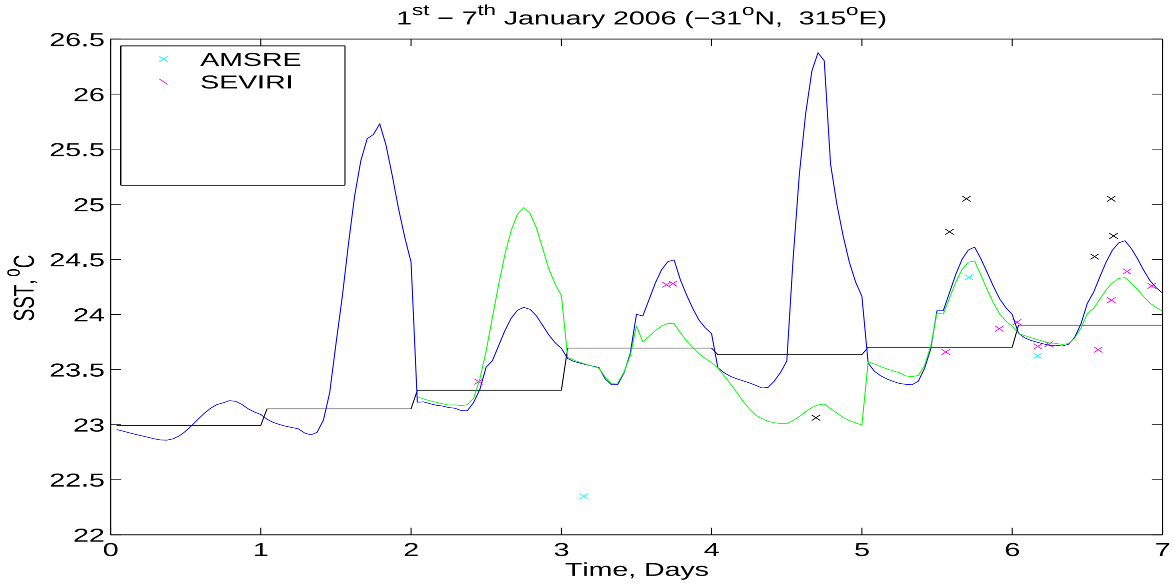
$$|J \; \epsilon_A^*, \epsilon_B^*| \leq |J \; \epsilon_A, \epsilon_B| .$$

t is possi e th t n incre se in c o d co er nd decre se in ind speeds nd ice ers co d pro ide the desired e ect n this scen rio o ser tions fro AM R E nd M if oth types R nd M of o ser tions re i e then on y the ind p r eter is t ned t if on y M o ser tions re i e then oth ind nd c o d p r eters re t ned to nderesti te the r ing on these occ sions o e er e r ier in the ee the ode ed di rn r ing esti tes re rger th n the o ser tions s ggest he d t ssi i tion ethod red ces the c o d if necess ry in the presence of E R o ser tions fo o ed y correction to the ind speed forcing nd then the c o d fr ctions hen E R o ser tions re not present he ssi i tion is e to red ce the ode ed r ing for d ys thro gh to nd incre se the di rn r ing on d ys nd th s tting the o ser tions ch ore c ose y On d ys nd the ssi i tion h s not een e to red ce the r ing s ch s the o ser tions o d s ggest n these c ses the syste does not f y dhere to the ss ptions of the ssi i tion ro tine either ec se the esti ted sensiti ity o er the p r eter r nge is in cc r te or the req ired ch nge in forcing is o tside the st ted restrictions

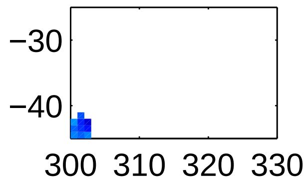


d y O [A sho s r i s co p red to the o ser tions nd this is i e y the c se of the ssi i tion r n to f i t this point

he ssi i tion is ess ro st if correction to the di rn cyc e is sed on sing e o ser tion p rtic r y if it occ rs e r y in the orning his c n e seen in Fig re here on d y s ight correction e r y in the r ing ph se e ds to rger di rn cyc e th t c n not e ttested y f rther o ser tions nd on d y here s res t of possi e erroneo s y coo o ser tion strong inds re sed to e i in te ny di rn cyc e hese e p es i str te ho the sche e co d e f rther i pro ed in the f t re y incorpor ting ore o ser tions nd i ding on the no edge g ined to for c ref tre t ent of o ser tion error oth syste tic nd r ndo ithin the ssi i tion cyc e



1st – 7th January 2006 (−31°N, 315°E)
AMSRE
SEVIRI
SST, °C
Time, Days
26.5
26
25.5
25
24.5
24
23.5
23
22.5
22
0
1
2
3
4
5
6
7


−30
−40
300
310
320
330

4.2 Comparing Di erent Satellite Observations

F rther n yses ere so perfor ed to ssess the errors ssoci ted ith indi id o ser tion types re ti e to the contro r n nd these re presented in e

	No O s	Me n	D	RM
GO M E ⌠R⌠		− .		
GO M AM RE				
GO M M⌠				

e **Results showing the number of observations, the mean, STD, and RMS of $\theta_{\mathrm{control}} - \theta_{\mathrm{obs}}$, in °C, for individual satellite types for the area − °N to − °N and °E to °E during st{ th January 2006.**

A si i r n er of E ⌠R⌠ nd AM RE o ser tions re i e o er the ti e period in this re ith s ight y fe er M⌠ o ser tions he ode o ser tion tch ps re e di erences et een the three s te ite instr ents he E ⌠R⌠ o ser tions re sho n to e on er ge r er th n the p r eterised s in te per t re here s the AM RE nd M⌠ o ser tions re coo er on er ge th n the ode ed his s ggests th t the o ser tions h e so e syste tic errors in this re t this ti e ith E ⌠R⌠ syste tic y too r nd or AM RE nd M⌠ o ser tions syste tic y too coo he ode co d so h e r i s nd e esti ting too gre t coo s in correction his see s n i e y s the p r eterised coo s in correction for this period s on er ge . °C i e s er th n the E ⌠R⌠ on y e n di erence he ode si tions re dependent on the O ⌠A t the st rt of e ch d y therefore ny errors in O ⌠A i so e pp rent see ection he D nd RM re signi c nt y o er hen co p ring E ⌠R⌠ o ser tions ith either AM RE or M⌠ he rgest errors re fo nd ith the M⌠ o ser tions here the RM error ppro ches °C

4.3 Day-Night Comparisons

Di erences in night ti e et een the restricted ho rs of oc ti e nd d yti e et een the ho rs oc ti e tch ps ere so ere so for heighten di rn cyc e nd dr s the ode c oser to the o ser tions he D nd RM di erences re in si i r for oth d y nd night

	Me n	D	RM
Before Assi i tion			
d yti e			
night ti e			
After Assi i tion			
d yti e			
night ti e			

e **Results showing the mean, STD, and RMS of $\theta_{\text{model}} - \theta_{\text{obs}}$, before and after the assimilation, in °C, during daytime (10{16) and night time (22{04) local time for the area – °N to – °N and °E to °E during st{ th January 2006.**

4.4 Comparisons to OSTIA

o he p deter ine to h t e tent the i ses re fo nd to e rger th n night ti e i ses nd hen co p ring o ser tions i s of − . °C is fo nd his indic tes th t the s te ite o ser tions on er ge re r er th n O ∫A s o d e e pected ec se O ∫A is rge y restricted to night ti e he sh rp di erence in d y nd night ti e e n es de onstr tes the presence of di rn sign s in the d yti e o ser tions O ∫A is the e n e of these o ser tions s e s others nd so the e pect tion is th t the i s o d e s ∫n this tch p o ser tions re inc ded here s O ∫A is for ed y e i in ting d yti e o ser tions t en ith ind speeds ess th n s⁻ hese ddition o ser tions re therefore contri ting to the s ight coo i s in

	No Os	Me n	RM	D
ECM F AMRE		− . − .		
A ıM AMRE		− .		
ECM F Mı		− . − .		
A ıM Mı		− .		
ECM F ALL		− . − .		
ssi ALL		−		

e **Results comparing the ECMWF forecast wind speeds before and after assimilation to the AMSRE and TMI wind measurements showing the number of observations, the mean, the RMS, and STD di erences in ms^{-}. For the area − °N to − °N and °E to °E during st{ th January 2006. The numbers in parenthesis are calculations only at the locations and times when wind speeds are corrected in the assimilation.**

ın this p per d t ssi i tion ethod h s een de e oped th t ssi i tes s te ite deri ed o ser tions into di rn cyc e ode ıt is proposed ho ode errors in di rn r ing esti tes re pri ri y c sed y ncert inties in N P forcing d t he di rn ri i ity of s c n e ie ed s f nction of ind speeds nd fr ction c o d co er O ser tions fro E ıRı AMRE nd Mı occ rring thro gho t the d y re co p red to their ode ed eq i ent he res ting di er ences re then red ced y ing corrections to the forcing ind speeds nd c o d co er his t ning of the forcing is sho n to res t in ode ed esti tes th t rese e i e o ser tions ch ore c ose y he ssi i tion ethod co d e ie ed s s oothing nd interpo ting the s te ite o ser tions in n inte igent nner he ethod is sho n for e p e to t the o ser tions etter th n O ıA hich ses d i y persistence ss ption

Most ssi i tion sche es do not se ertic corre tion sc es hen inserting o ser tions nd s seq ent y re n e to pro ide d st ents to the s s rf ce ther odyn ic str ct re this red ces the e ecti eness of n ssi i tion o e er y correcting ind speed nd c o d co er es ithin ncert inty o nds the ethod presented here tte pts to preser e the nce of ther nd dyn ic e ds ithin the di rn ther oc ine

his ssi i tion ethod co d e i p e ented on ch ider sc e to i d p det i ed re ti e pict re of di rn r ing cross the or d s oce ns he distri tion nd gnit de of di rn sign s re sti re ti e y n no n nd this techniq e of erging o ser tions ith di rn cyc e ode co d e sed to i pro e this sit tion Another pp ic tion co d e to se this techniq e to c c te fo n d tion te per t res of incre sed cc r cy For e t p e of

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